U.S. EPA Superfund Program's Need for Model Comparison for Radioactive Contamination

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Purpose

- Briefly describe EPA need for a study comparing risk and dose models for evaluating radioactively contaminated sites

Improving Superfund models

- EPA's Superfund models undergo extensive internal reviews and external peer and verification reviews.
- A comparison study would provide another method for potentially improving the EPA Superfund models by seeing if other models had:
  - More updated science
  - Routes of exposure addressed that may be relevant for Superfund sites.

Inspiration: Previous EU Study on Chemical Risk Assessment Models

- Analyzed basis of screening values used in EU Member States and initiated a discussion on the reasons for their differences.
- "Derivation Methods of Soil Screening Values in Europe. A Review and Evaluation of National Procedures Towards Harmonization" (issued 2007, 320 pages)

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EU Models and Pathways Studied

Table 3.5. Pathways of exposure considered in the derivation of soil screening values in the investigated countries

	PATHWAYS	AUT	BE(W)	BE(F)	DEU	DNK	ESP	FIN	ITA	LTU	NDL	SWE	UK
Soil outdoor exposure	Soil ingestion	X	X	X	X	X	X	X	X	X	X	X	X
	Dust ingestion		X	X	X	X	X	X	X	X	X	X	X
	Dermal exposure		X	X	X	X	X	X	X	X	X	X	X
	Inhalation of soil vapors		X	X	X	X	X	X	X		X		X
	Inhalation of soil derived dust		X	X	X	X		X	X	X	X	X	X
Soil indoor exposure	Dermal exposure to soil derived dust		X	X				X	X			X	X
	Inhalation of soil originated vapors		X	X				X	X		X	X	X
	Inhalation of groundwater vapors										X		
Soil derived diet exposure	Consumption of homegrown vegetables		X	X	X			X		X	X	X	X
	Ingestion of soil attached to homegrown vegetables				X			X			X		X
	Consumption of homegrown fruits				X					X		X	
	Ingestion of soil attached to homegrown fruits				X								
	Consumption of meat			X									
	Consumption of dairy products			X									
Soil-Groundwater pathways	Consumption of groundwater		X		X				X		X	X	
	Drinking-water contaminated by permeation through pipes		X	X				X					
	Inhalation of volatilized domestic water							X			X		
	Showering (dermal contact + inhalation)		X	X				X			X		
Soil- surface water	Swimming: dermal contact + water ingestion + suspended matter ingestion												
	Consumption of fish and shellfish											X	

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EU Study: Summary of Residential Screening Levels

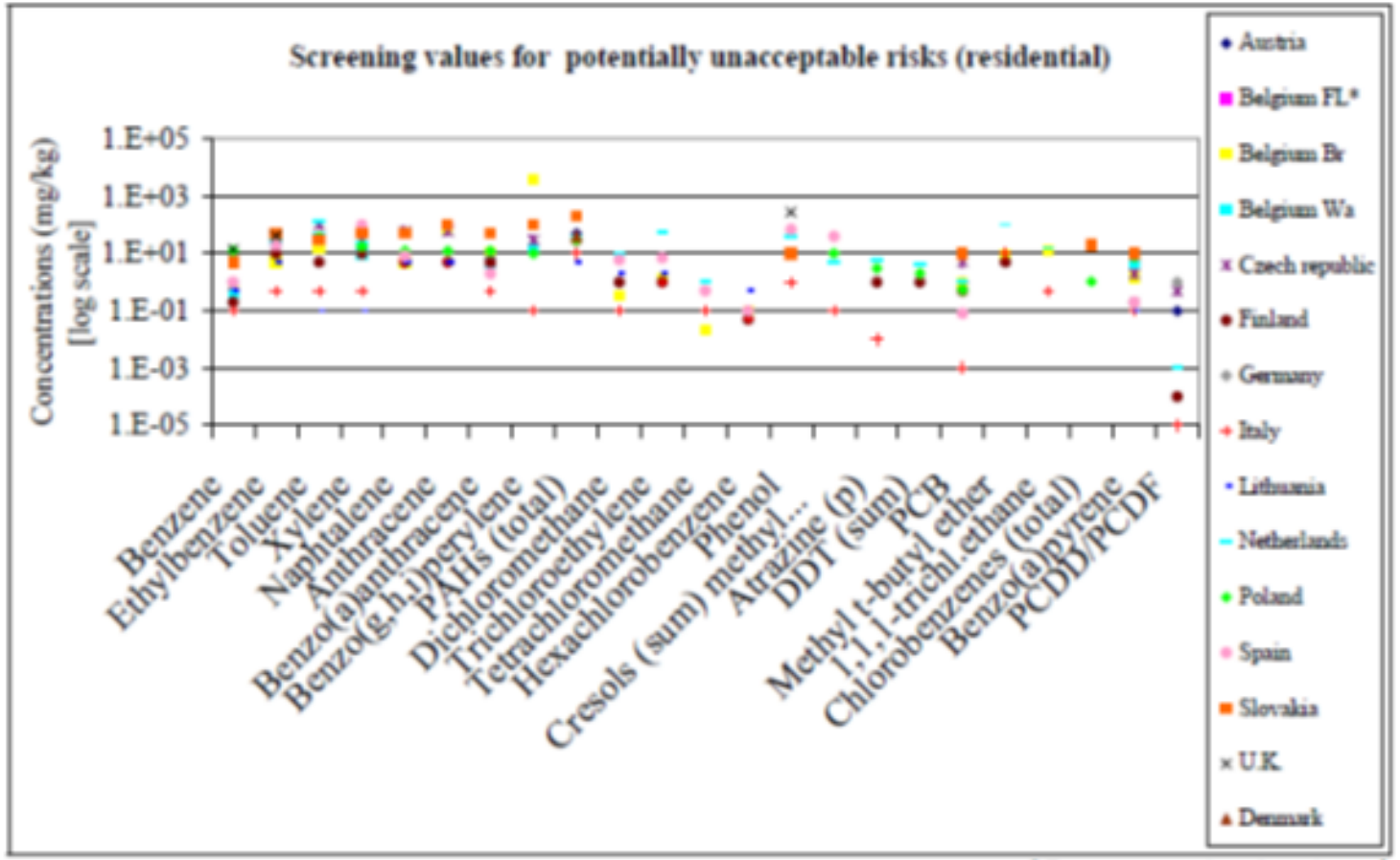

Figure 4.6. Screening values for potentially unacceptable risk (residential soil-use) for the most relevant organic contaminants.

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EU Study: Summary of Industrial/ Commercial Screening Levels

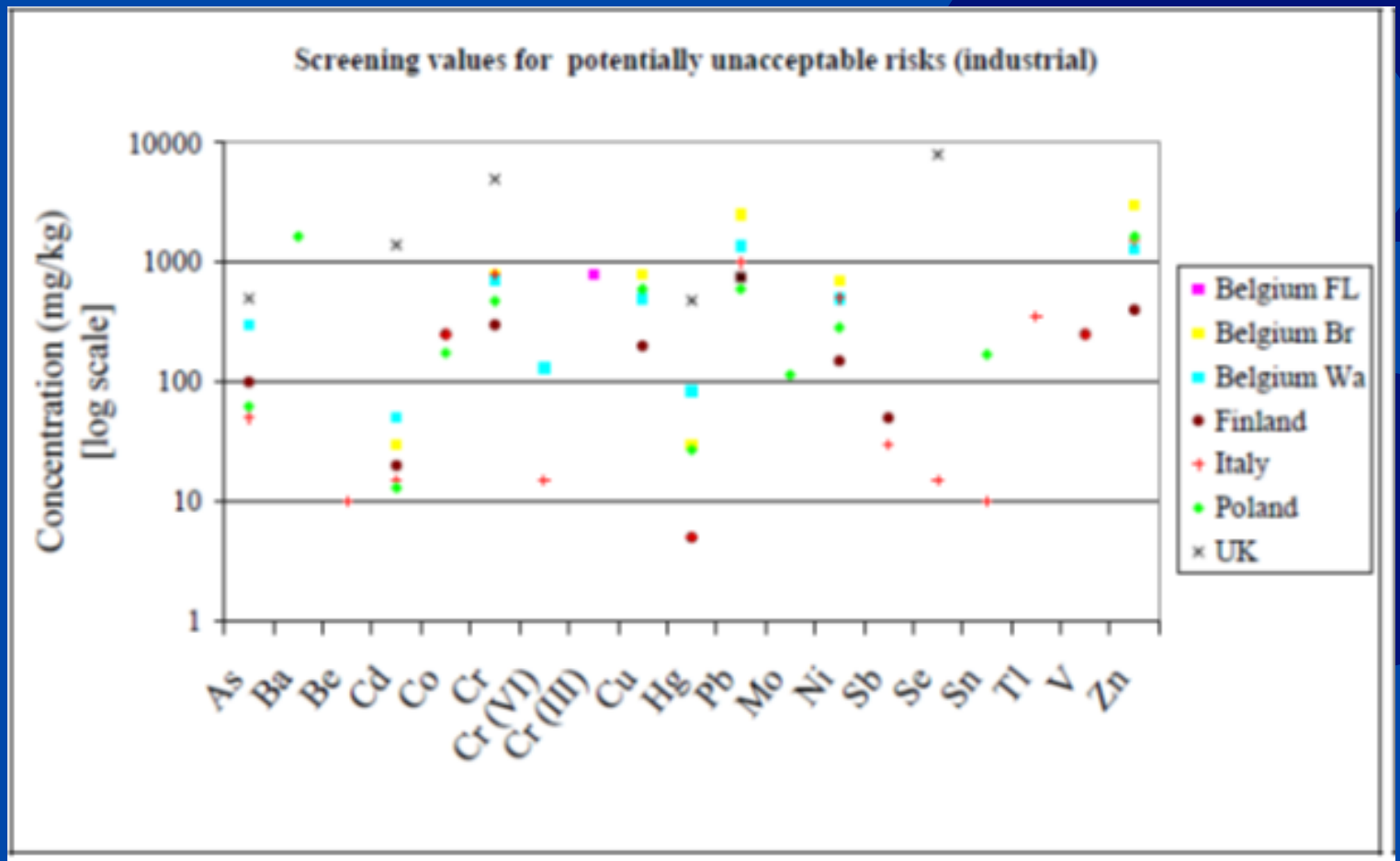
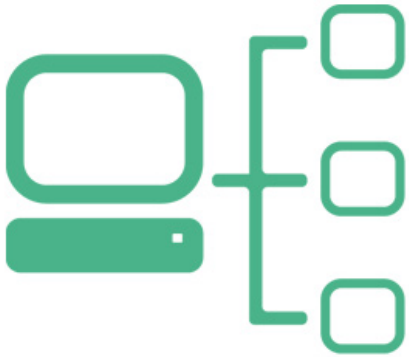


Figure 4.7. Screening values for potentially unacceptable risk (industrial soil-use) for the metals and metalloids.

Studies of Risk and Dose Assessment models for Radioactively Contaminated Soil at Sites, Contaminated Buildings and Contaminated Surfaces



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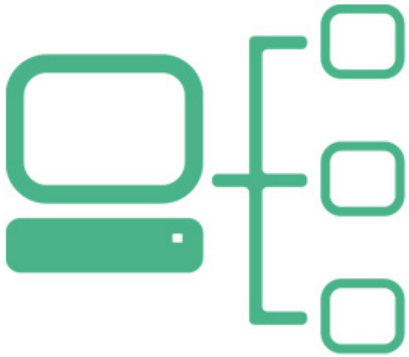
Objectives

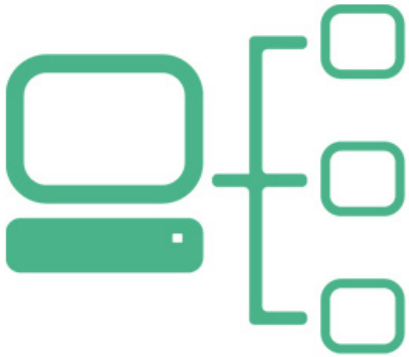
1. To make internal recommendations on technical and practical issues to the OSRTI.
2. Facilitating better understanding of each agency's modeling approach.
3. Identifying the similarities and differences between these agencies in the risk assessment of radioactively and chemically contaminated sites.

First Project

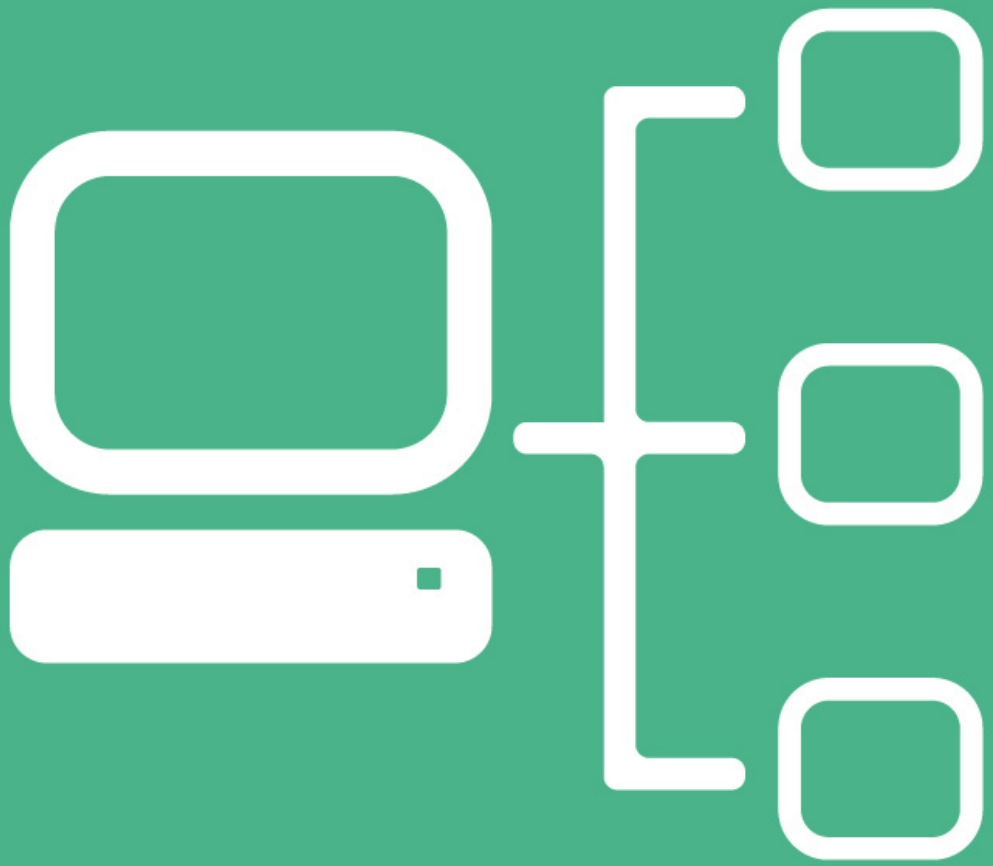


Overview of Radiation Risk and Dose Assessment Models for Radioactively Contaminated Sites and Selected Default Input Parameters

Outline



- Models Overview
- Parameters Comparison

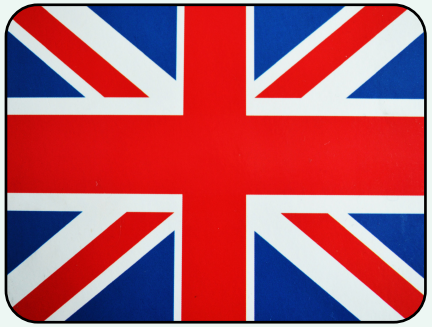


Models that address Contaminated Soil: Overview

United States

(PRG) Preliminary Remediation Goals	**(DCC)** Dose Compliance Concentrations	**(RESRAD) On-site** RESidual RADioactive material guidelines	**(RaSoRS)** Radioactive Soil Remediation Standards	**NCRP Report No. 129** Recommended Screening Limits for Contaminated Surface Soil and Review of Factors Relevant to Site Specific Studies

International



CROM

Screening Model for Environmental Assessment

WISMUT

“Wismut” is referred to the areas in Saxony and Thuringia in Germany

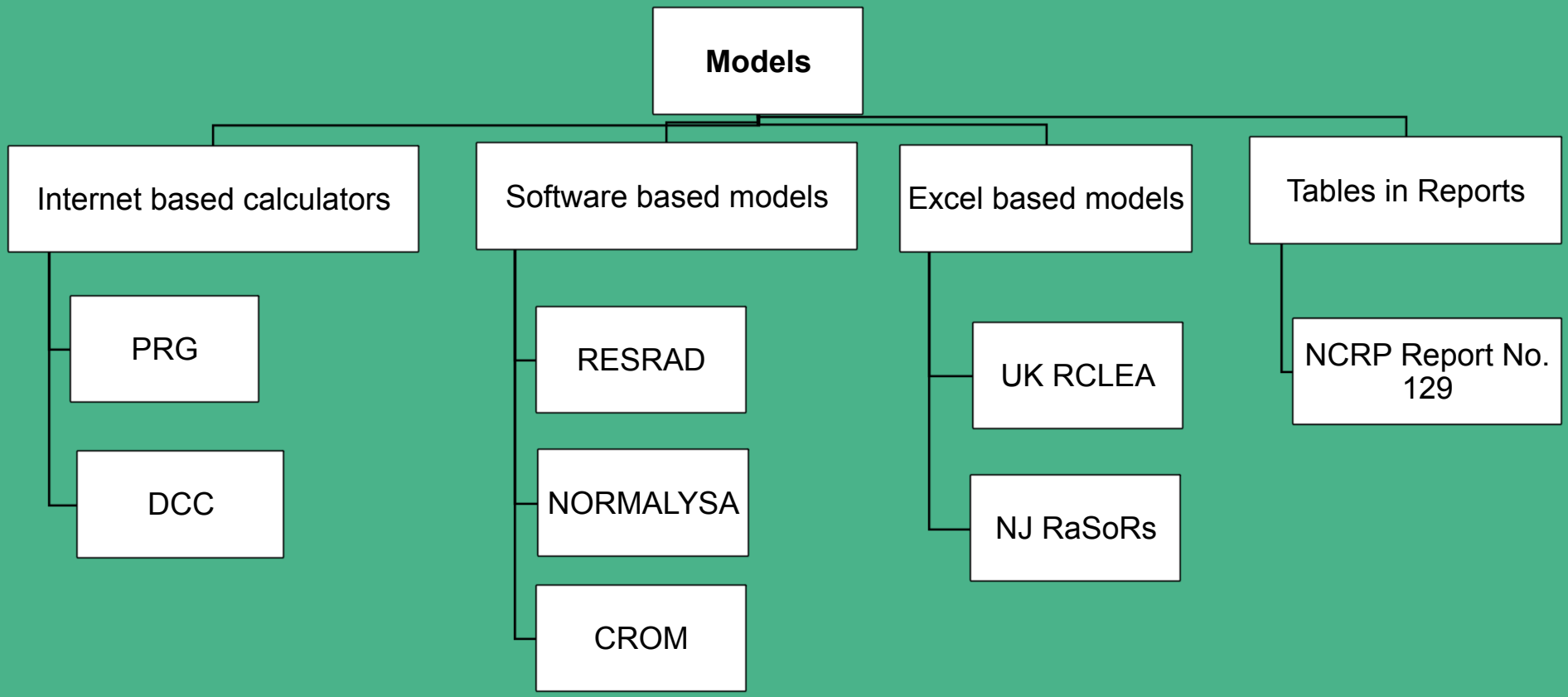
RCLEA

The Radioactively Contaminated Land Exposure Assessment Methodology

NORMALYSA

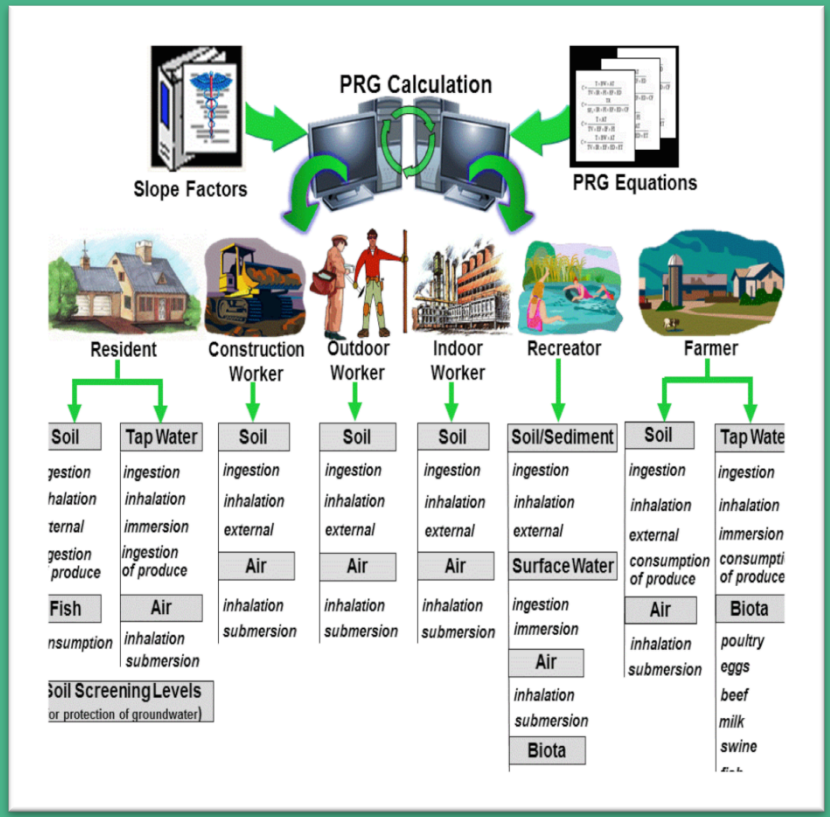
NORM And LegacY Site Assessment

Models



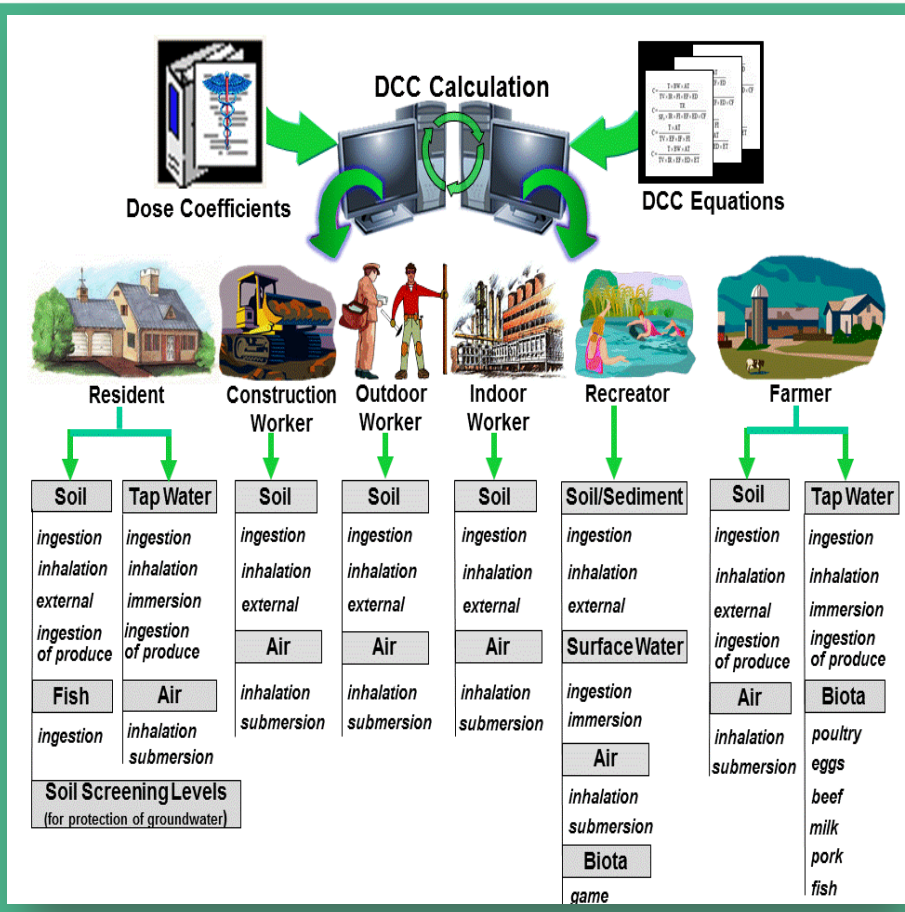
PRG Calculator

- PRG was developed by the U.S. Environmental Protection Agency(EPA) in 2002 and last updated in 2017.
- The PRG calculator is also consistent with EPA's recommended model for risk assessment for chemicals in soil, water, and air, the Regional Screening Level (RSL) calculator.



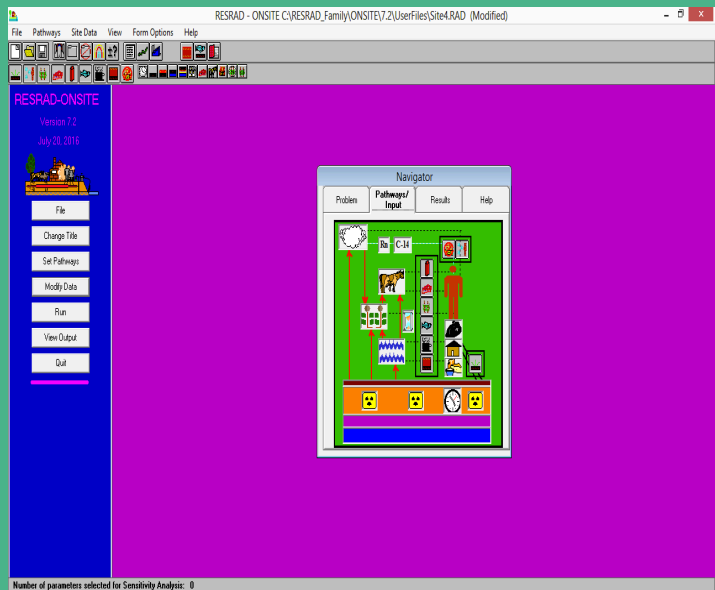
DCC Calculator

- The Dose Compliance Concentrations (DCC) calculator was first issued in 2004 and last updated in 2017.
- The DCC calculator is similar to the PRG calculator for demonstrating compliance with dose based regulations.



RESRAD (onsite)

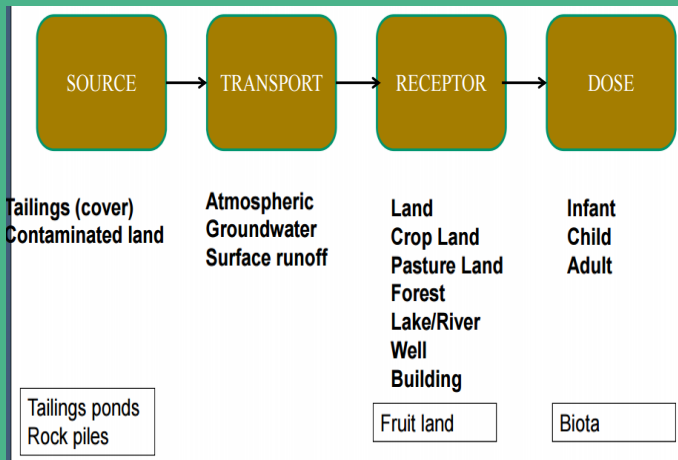
- RESidual RADioactive material guidelines, RESRAD was developed by Argonne National Laboratory for the U.S. Department of Energy in 1989 and updated last in 2016.
- To calculate:
  1. Site-specific guidelines,
  2. radiation doses and
  3. excess lifetime cancer risk.



NORMALYSA

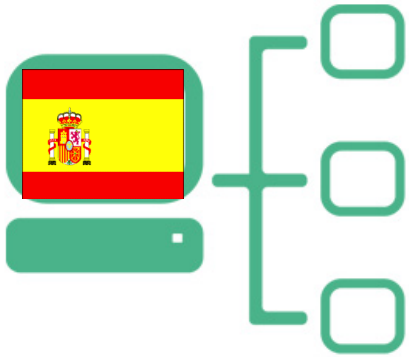
- NORM And LegacY Site Assessment (NORMALYSA) was developed by the International Atomic Energy Agency (IAEA) & adopted by Sweden.

- Library of models organized in four different modules:
  - Source
  - Transport
  - Receptor
  - Dose
- NORMALYSA has no user's manual.



GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA E INNOVACIÓN Ciemat Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

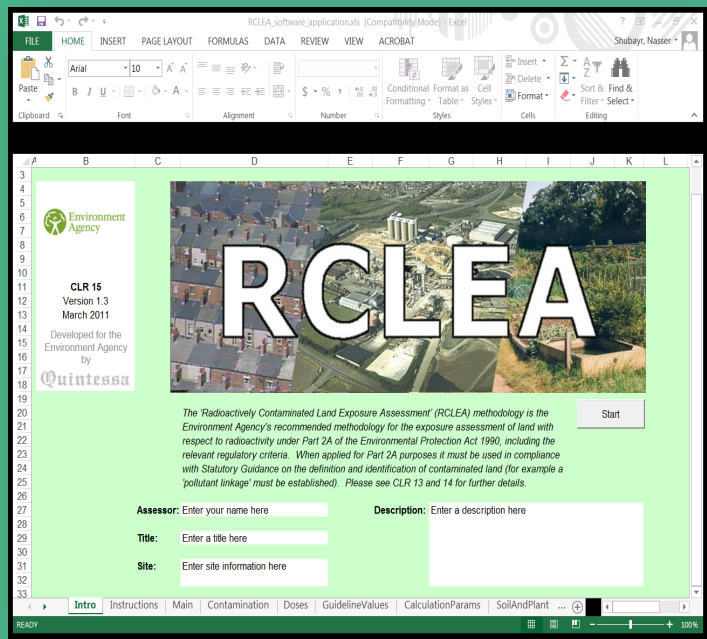
CROM



- CROM was developed by the University of Madrid and the Environmental Impact of the Energy Department (CIEMAT) in Spain.
- CROM was first issued in 2011 and updated last in 2016.
- CROM contains a default database with about 150 Radionuclides.
- CROM can be used to assess the impact of discharges of radionuclides to the environment. It can be used for continuous and prolonged release.

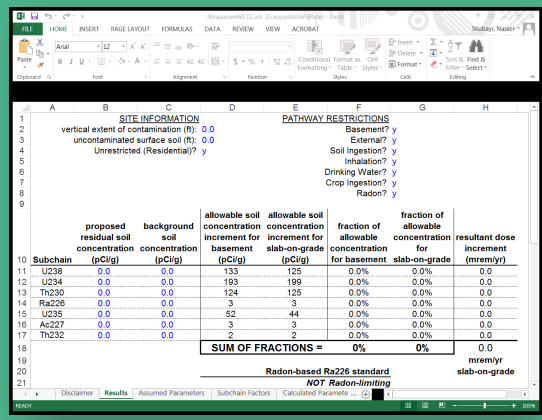
RCLEA

- RCLEA was developed by DEFRA's (U.K. Government Department for Environment, Food and Rural Affairs) in 2003
- RCLEA consists of a collection of worksheets (pages) that contain all input data and results.
- RCLEA considers a set of 47 radionuclides that are commonly found in radioactively contaminated sites in the UK.
- It can be used for generic or site-specific assessments.
- RCLEA is consistent with the UK chemical model, CLEA.



NJ RaSoRs

- **Ra**dioactive **So**il **R**emediation **S**tandards (RaSoRS).
- RaSoRS is an Excel based model developed by the Bureau of Environmental Radiation of the State of New Jersey in 2003.
- NJ RaSoRs contains:
  - Only 7 radionuclides and their progenies, (U-238, U-234, Th-230, Ra-226, U-235, Ac-227 and Th-232).
  - and assumes **two construction scenarios** (Basement and Slap-on-Grade)
  - For **two site use scenarios** (Residential and Commercial).



SITE INFORMATION

vertical extent of contamination (ft): 0.0
uncontaminated surface soil (ft): 0.0
Unrestricted (Residential)? y

PATHWAY RESTRICTIONS

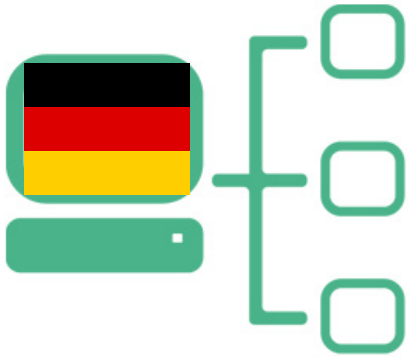
Basement? y
External? y
Soil Ingestion? y
Inhalation? y
Drinking Water? y
Crop Ingestion? y
Radon? y

Subchain	proposed residual soil concentration (pCi/g)	background soil concentration (pCi/g)	allowable soil concentration increment for basement (pCi/g)	allowable soil concentration increment for slab-on-grade (pCi/g)	fraction of allowable concentration for basement	fraction of allowable concentration for slab-on-grade	resultant dose increment (mrem/yr)
U238	0.0	0.0	133	125	0.0%	0.0%	0.0
U234	0.0	0.0	193	199	0.0%	0.0%	0.0
Th230	0.0	0.0	124	125	0.0%	0.0%	0.0
Ra226	0.0	0.0	3	3	0.0%	0.0%	0.0
U235	0.0	0.0	52	44	0.0%	0.0%	0.0
Ac227	0.0	0.0	3	3	0.0%	0.0%	0.0
Th232	0.0	0.0	2	2	0.0%	0.0%	0.0
			SUM OF FRACTIONS =		0%	0%	0.0
							mrem/yr
			Radon-based Ra226 standard				slab-on-grade
			NOT Radon-limiting				

WISMUT

- WISMUT was developed by the Germany Federal Laender and the Wismut GmbH company.
- The name “Wismut” is referred to an area in Germany that were adversely affected by 40 years of unrestrained mining and processing of uranium ores.
- WISMUT was developed with special considerations for the WISMUT region such levels of natural background for all relevant environmental media in the area.

WISMUT (cont.)



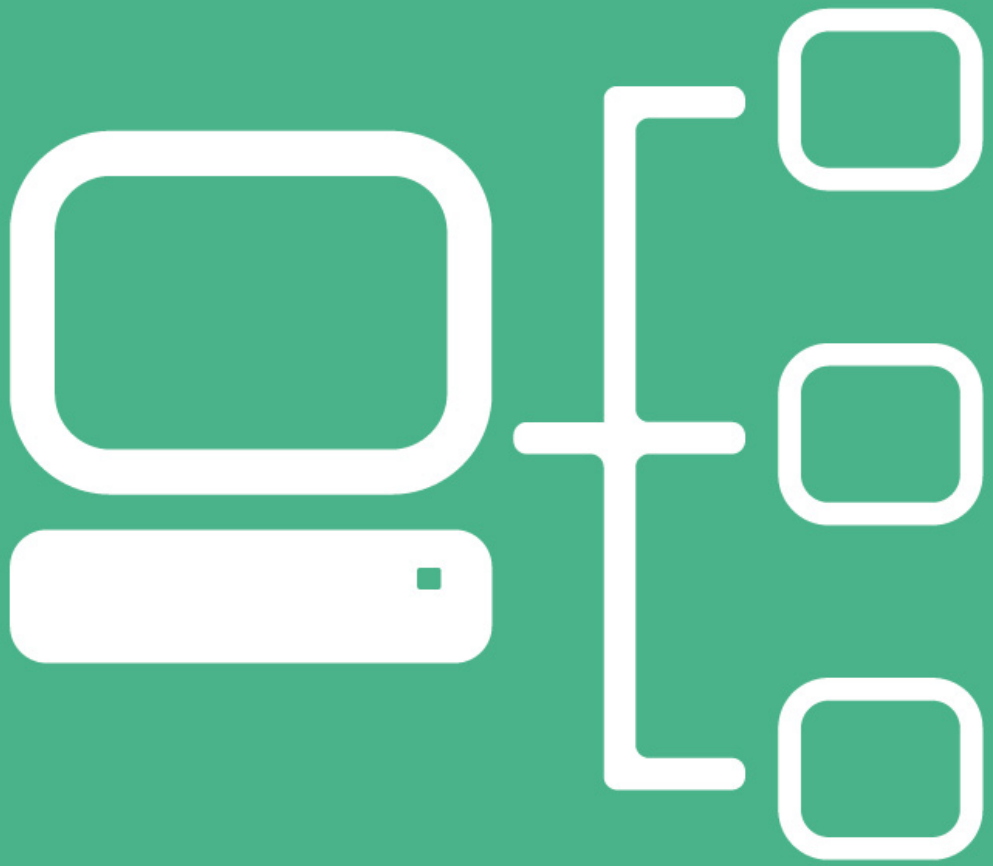
- To assess radiation exposure of members of the public and workers due to environmental radioactivity resulting from mining.
- It is applicable for remediation, decommissioning, reuse of mining plants.
- WISMUT is not available in English and not accessible due to copyright agreement.

National Council on Radiation Protection and Measurements

NCRP Report No. 129

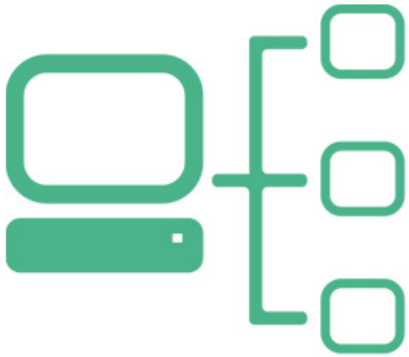
National Council on Radiation Protection and Measurements (NCRP) published a report entitled, “Recommended Screening Limits for Contaminated Surface Soil and Review of Factors Relevant to Site Specific Studies” (NCRP Report No. 129)

It lists screening guidance for over 200 radionuclides with half-lives greater than 30 days.



Default Input Parameters Comparison

Default Input Parameters

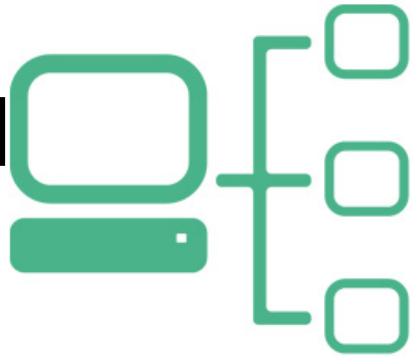


- Physiological Factors
- Dietary Factors for Human Food Consumption
- Soil Consumption
- Animal Consumption Rates
- Shielding Factors
- Occupancy Factors
- Mass Loading Factor

Physiological Factors

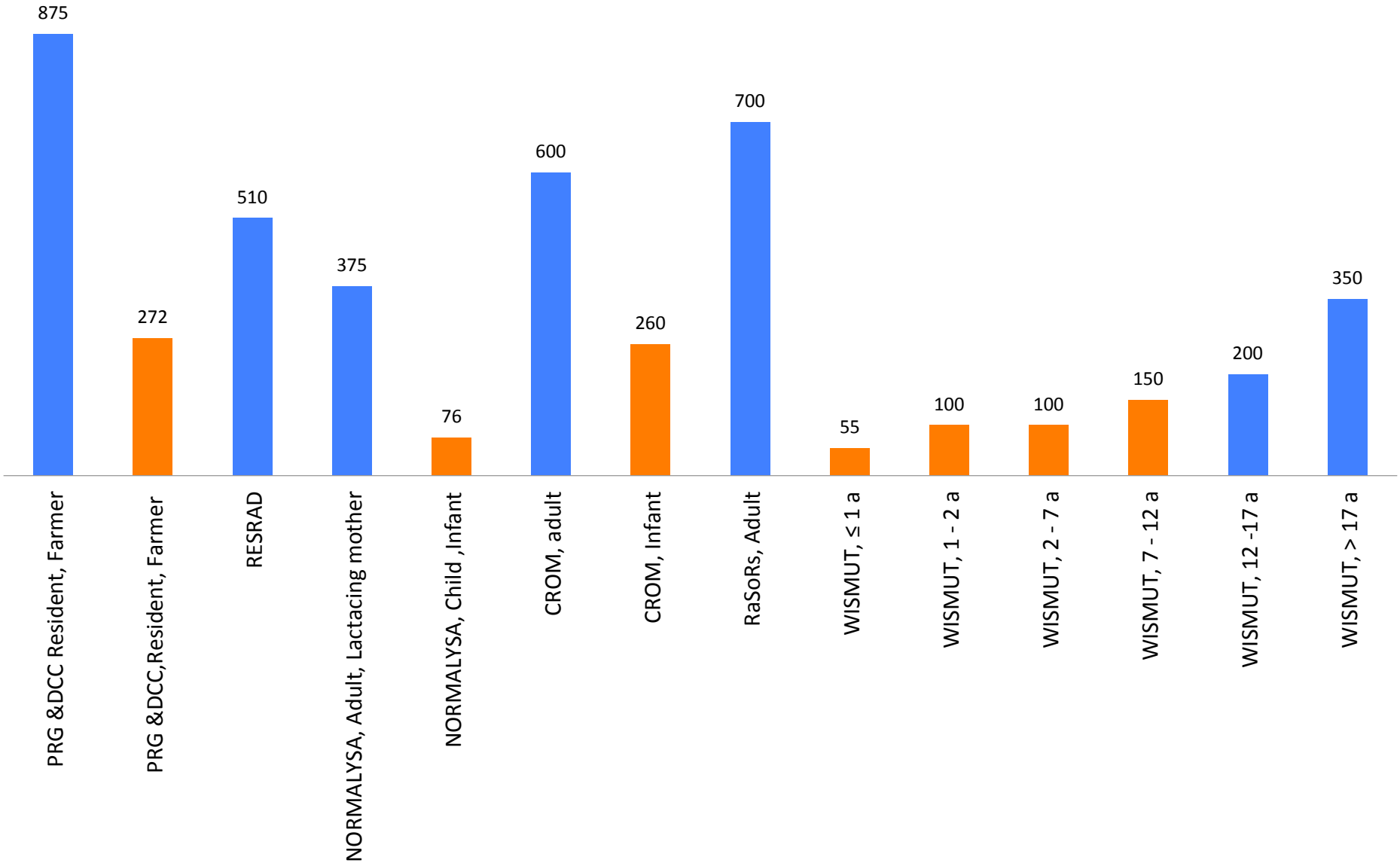
Model	Sex	Age	Breathing Rates (m^3/h)			
PRG, DCC, RSL	N/A	Child	0.41	Resident, Recreator, Farmer		
		Adult	0.83	Resident, Recreator, Farmer		
			2.5	Construction & Composite Worker		
RESRAD (ON-SITE)	N/A	Adult	Resident Farmer	Suburban Resident	Industrial Worker	Recreationist
			0.95	0.95	1.3	1.6
NORMALYSA	N/A	Infant	0.92			
		Child	0.64			
RCLEA*			Active	Passive		
	Male	Infant	0.339	0.124		
		Child	1.103	0.404		
		Adult	1.456	0.485		
	Female	Infant	0.32	0.117		
		Child	1.1	0.403		
		Adult	1.234	0.411		
CROM	N/A	Adult	0.95			
		Infant	0.16			
		0-1	0.16			
		1--2	0.22			
		2--7	0.36			
		7--12	0.64			
		12--17	0.84			
		>17	0.95			
RaSoRS	N/A	Adult		Indoor on site	Outdoor on site	
			Residential	0.63	1.4	
			Commercial	1.4	1.4	
WISMUT	N/A	≤ 1	0.12			
		1 - 2	0.22			
		2 - 7	0.36			
		7 - 12	0.64			
		12 -17	0.84			
		> 17	0.93			
		Worker	1.2			
NCRP	N/A	Adult	Land-use		Outdoor	Indoor
			Agricultural		1.4	-
			Heavily Vegetated Pasture		1.4	-
			Sparsely vegetated pasture		1.4	-
			Heavily Vegetated rural		1.25	0.83
			Sparsely Vegetated rural		1.25	0.83
			Suburban		1.04	0.83
			Construction, etc.		1.4	-

Dietary factors for human food consumption

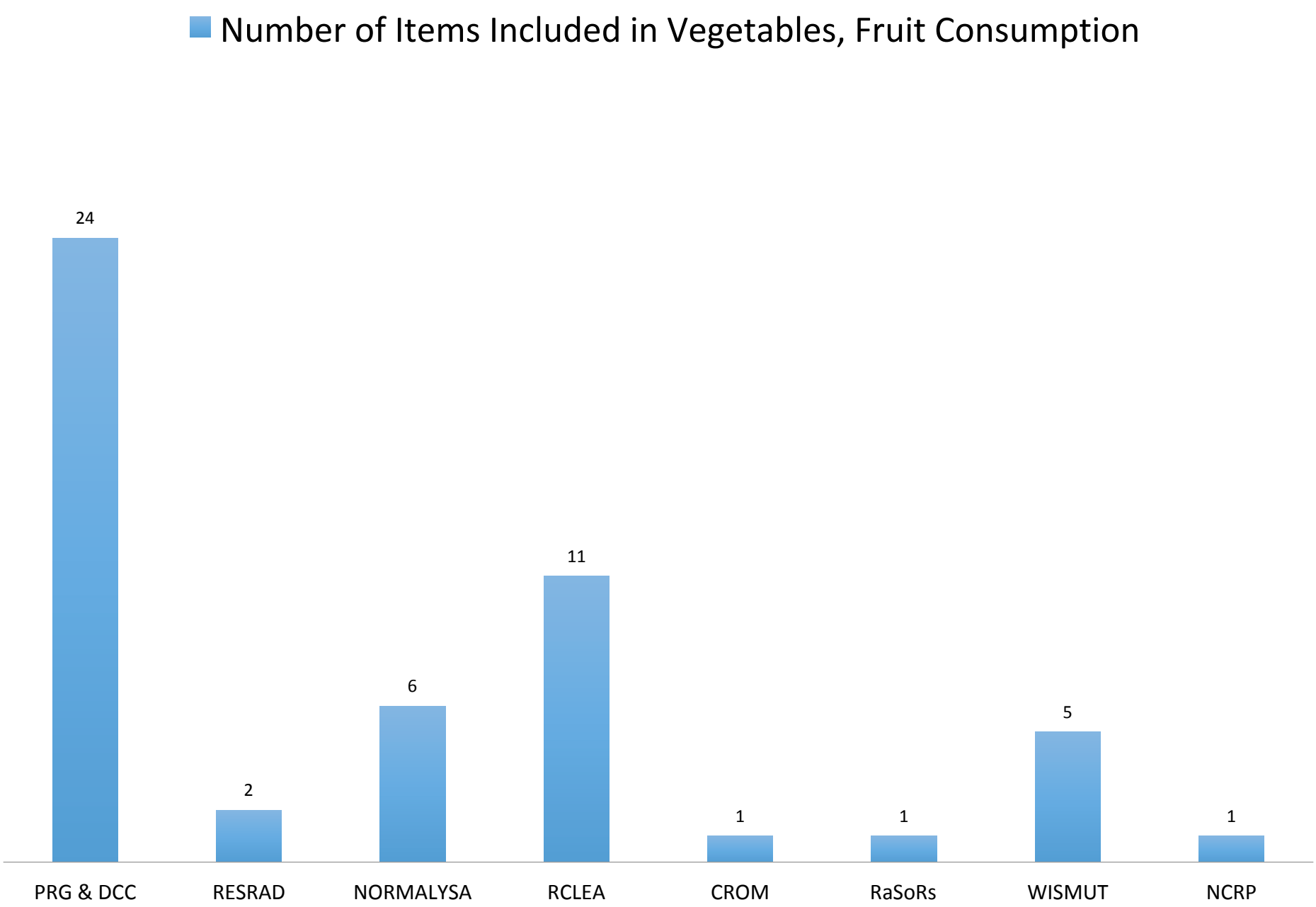


- Drinking Water Consumption
- Fruits, Vegetables and Grain Consumption
- Milk / Dairy Consumption
- Meat And Poultry Consumption
- Fish & Seafood Consumption

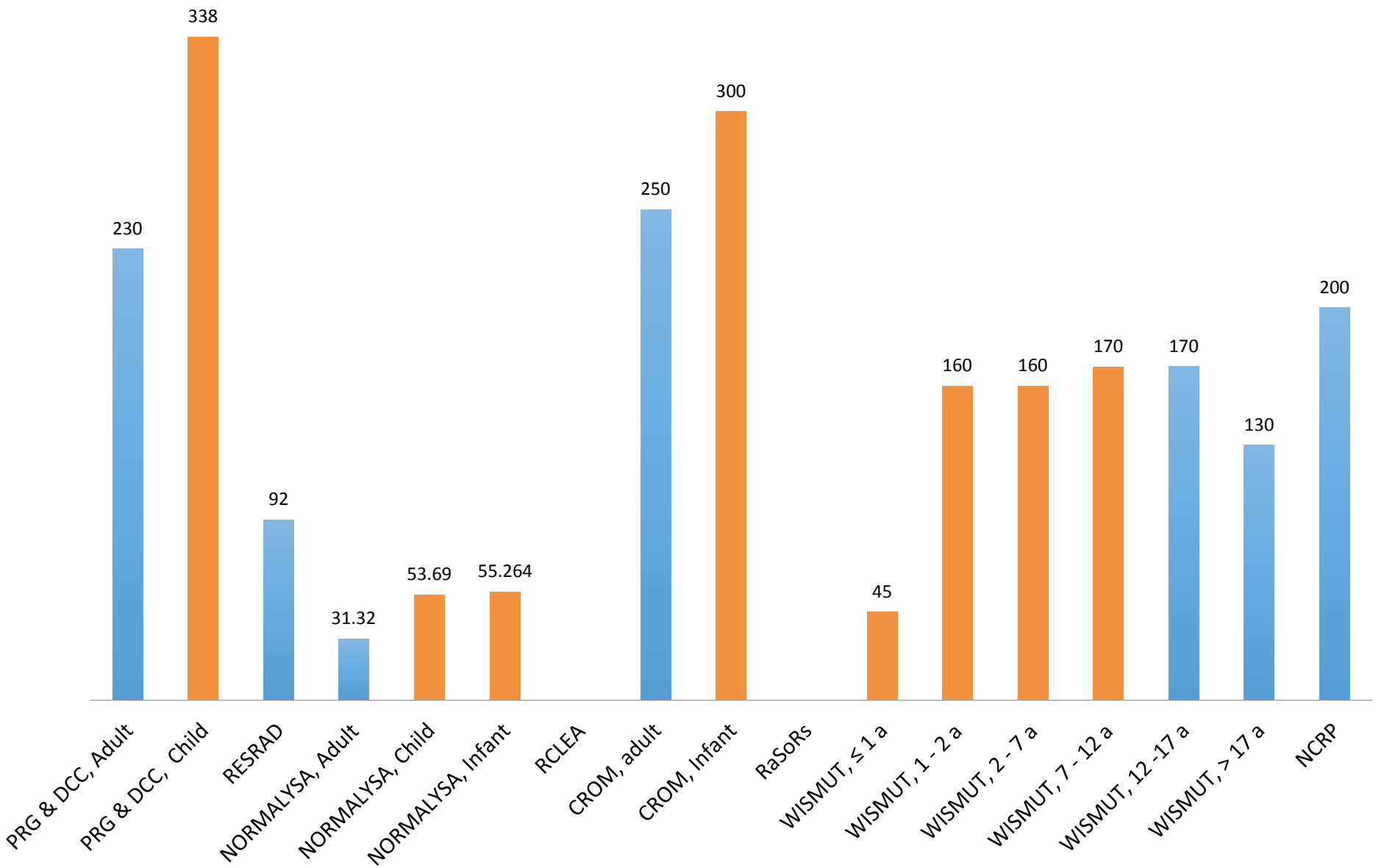
Drinking Water Consumption (Liter/year)
Blue: Adult
Orange: Child & Infant



Fruits, vegetables and grain consumption



Milk/ Dairy Consumption (Liter/year)



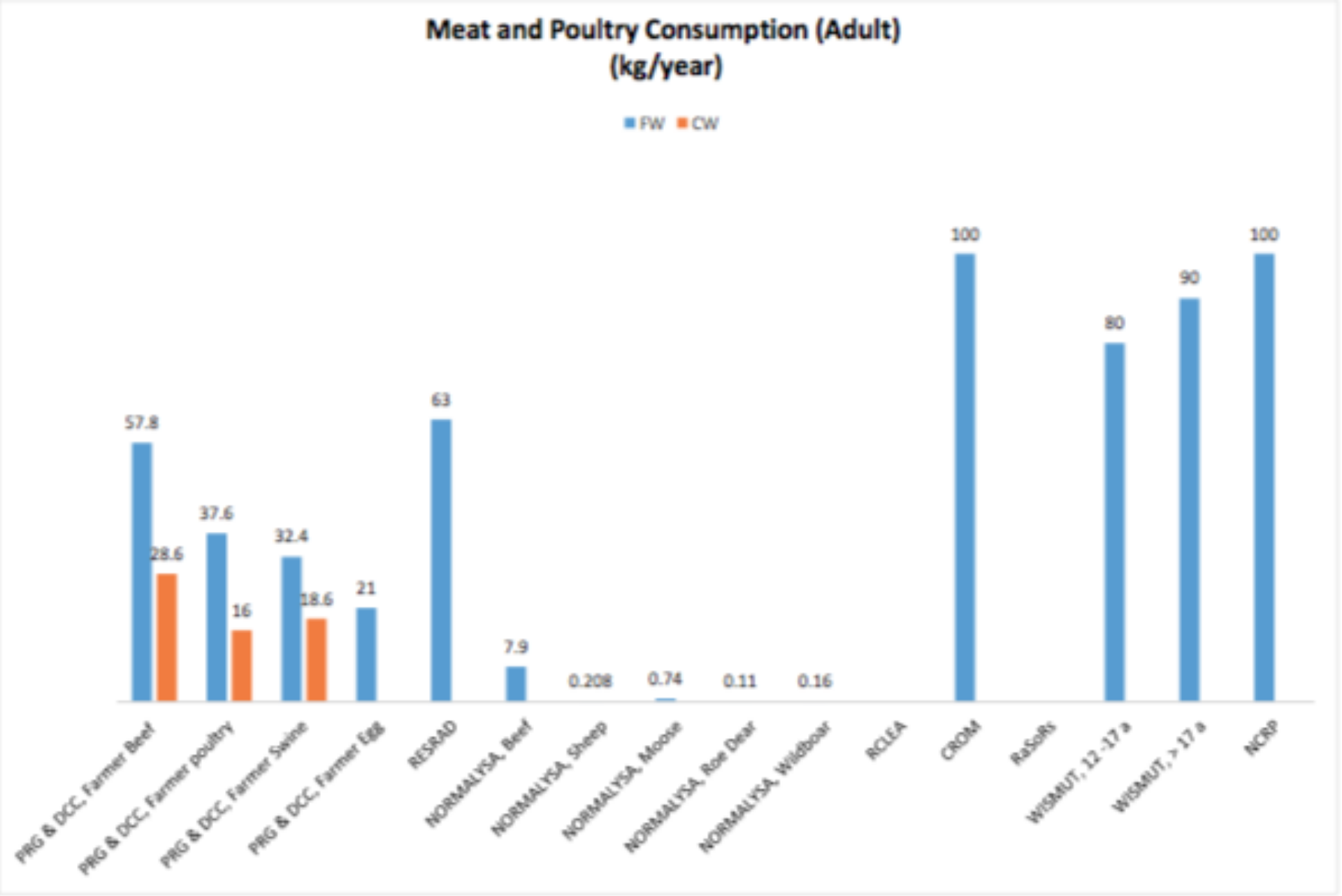


Figure 10: Meat and Poultry consumption rates for adult (kg/yr).

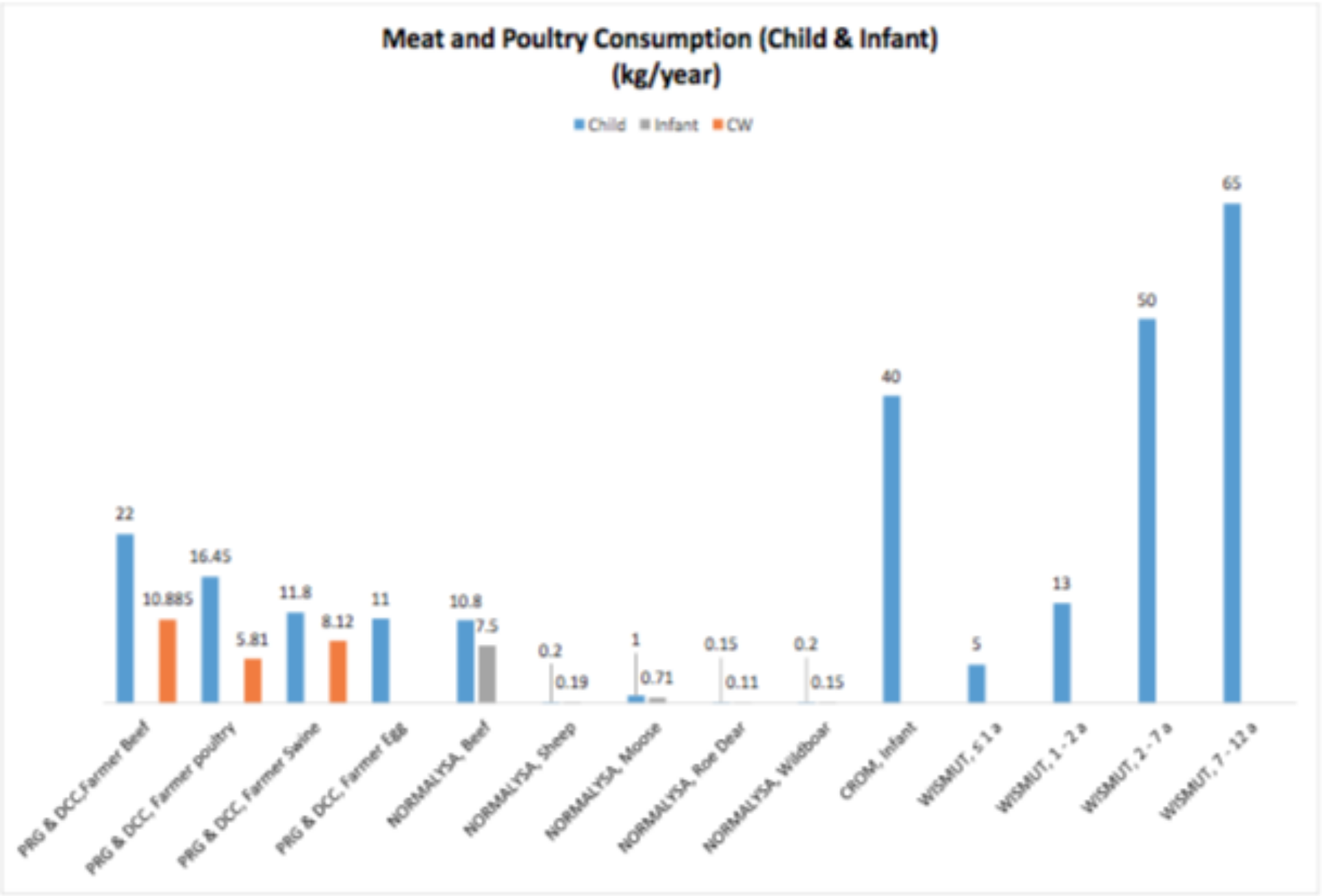


Figure 11: Meat and Poultry consumption (child & infant) (kg/yr).

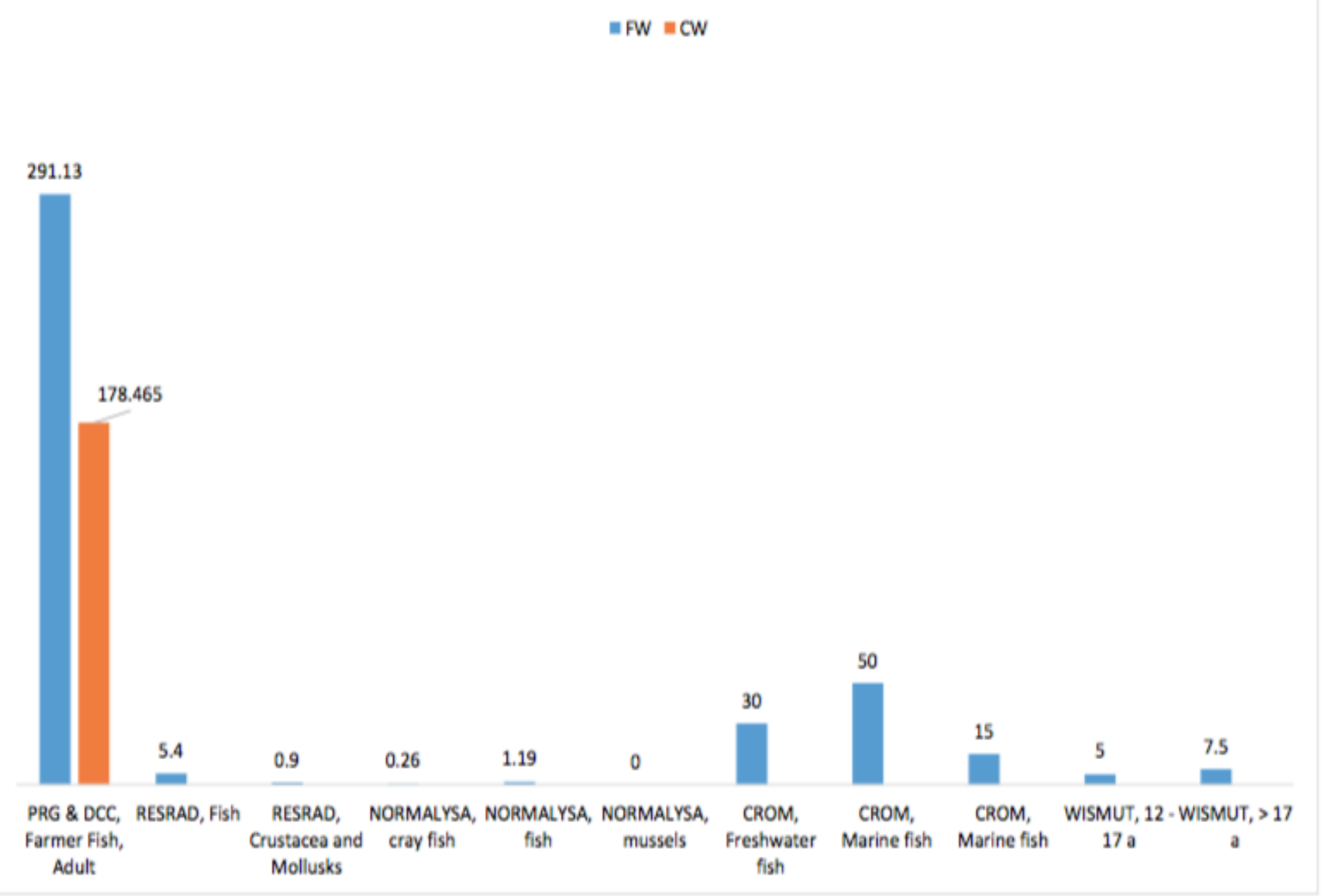


Figure 12: Fish & Seafood consumption for adult.

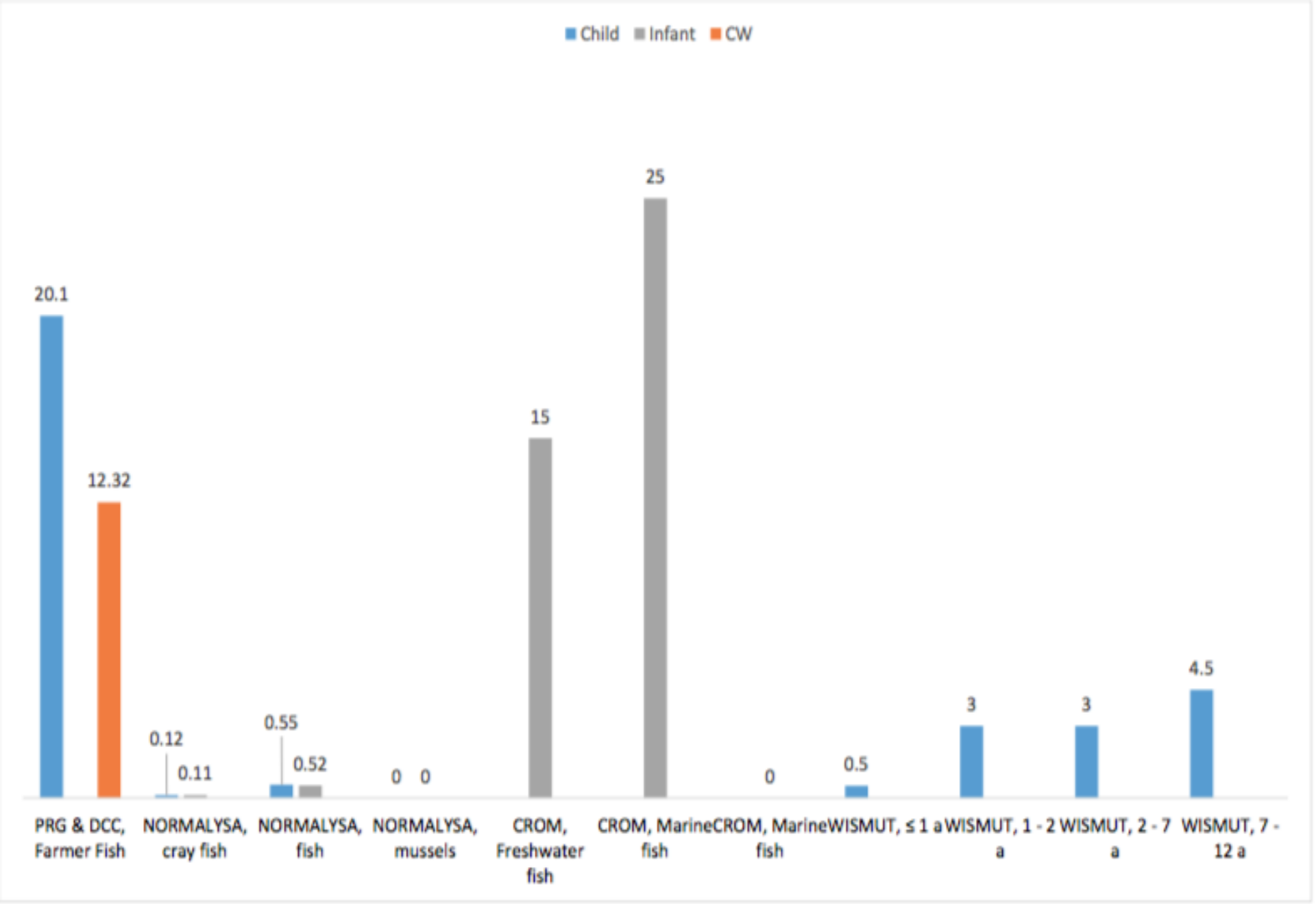


Figure 13: Fish & Seafood consumption for infant and child.

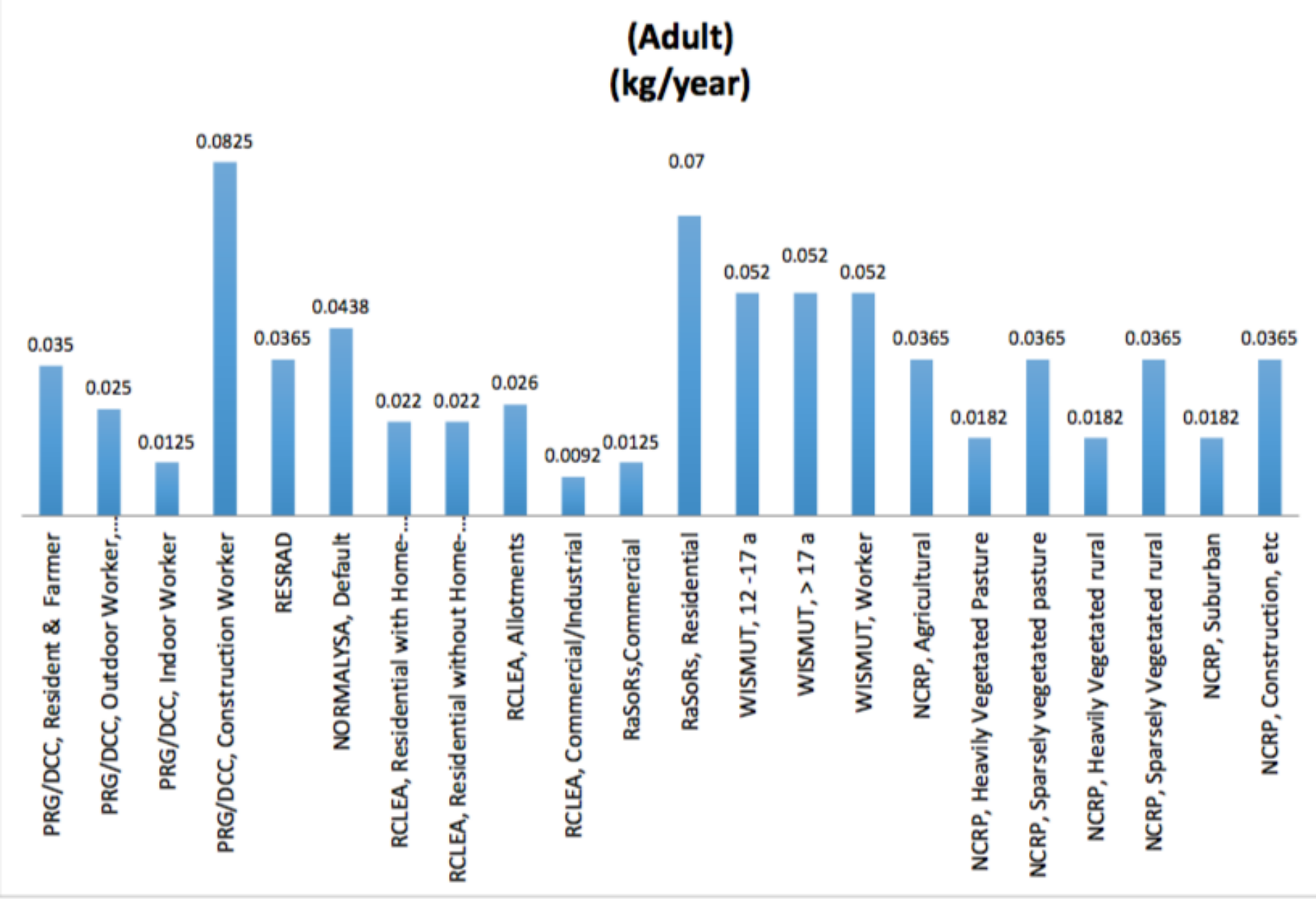


Figure 15: Soil consumption rates for adult (kg/yr).

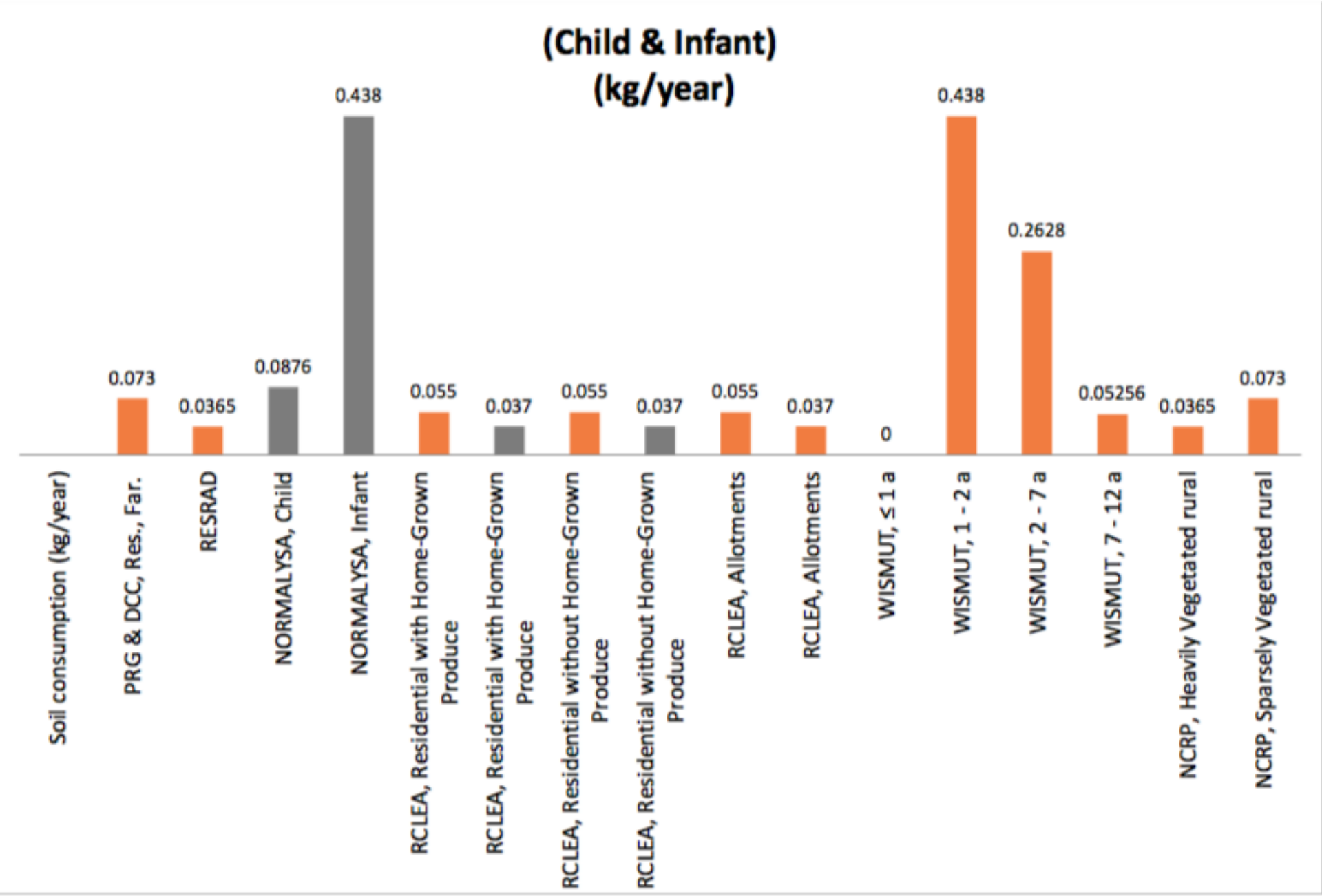
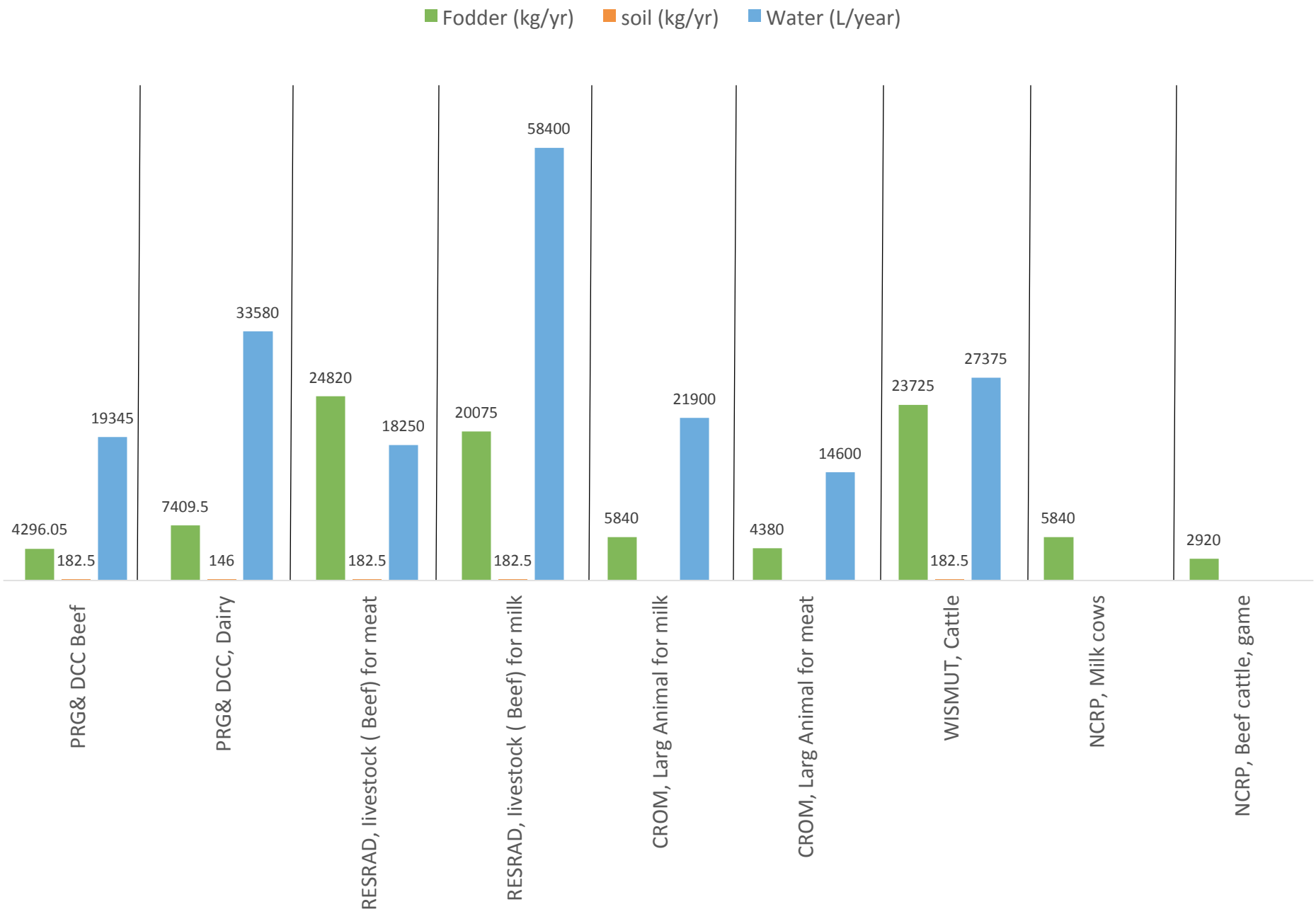


Figure 16: Soil consumption rates for child (orange) and infant (gray) (kg/yr).

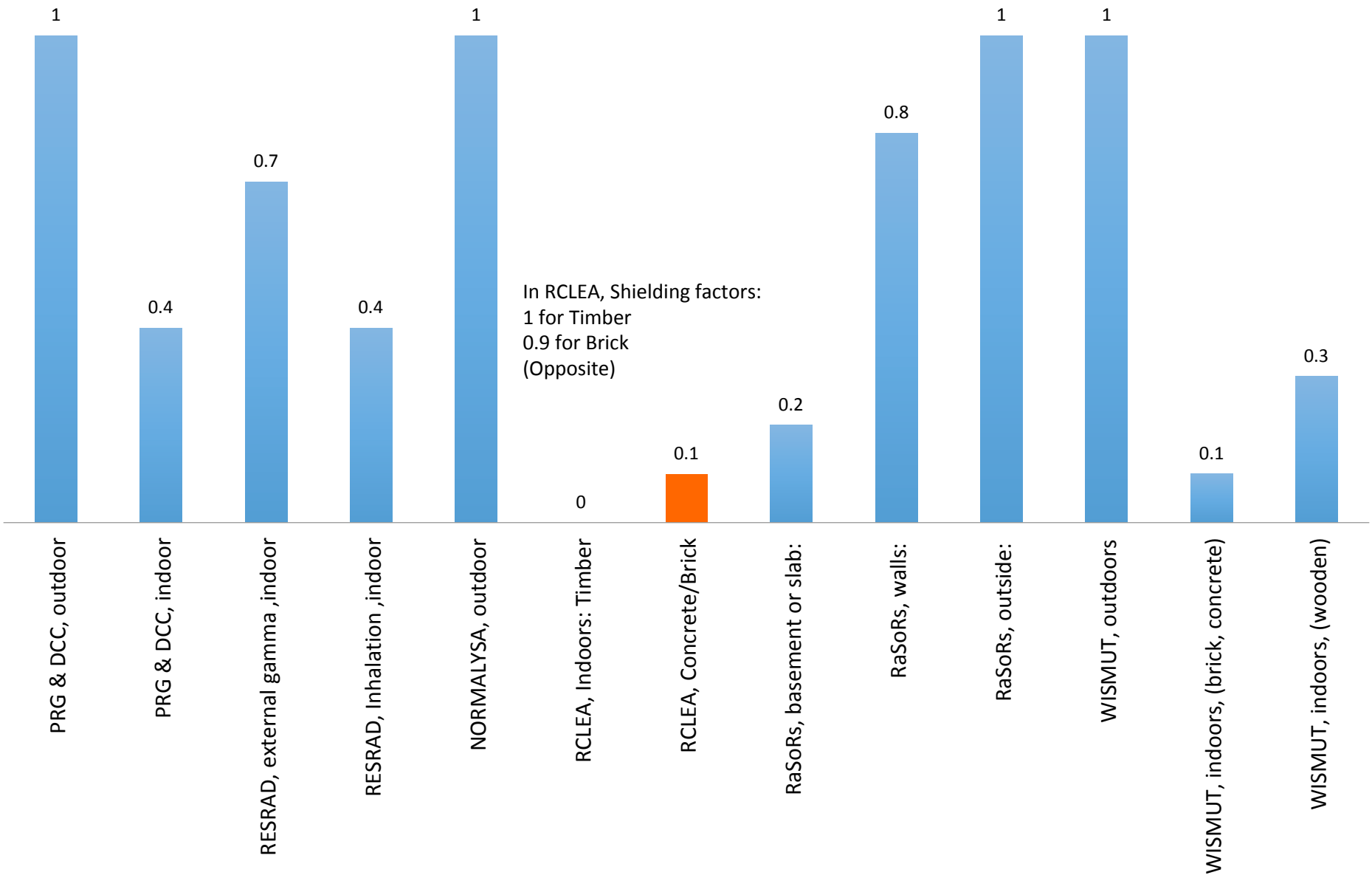
Animal Consumption Rates

	Fodder	Soil	Water	Number of animals
PRG & DCC	*	*	*	12
RESRAD-ONSITE	*	*	*	2
NORMALYSA	*	*	*	2
RCLEA	-	-	-	-
CROM	*	-	*	2
RaSoRS	-	-	-	-
WISMUT	*	*	*	1
NCRP	*	-	-	6

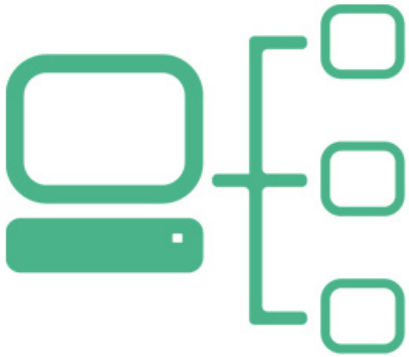
Cows' Fodder, Soil and Water Consumption Rates



Shielding factors

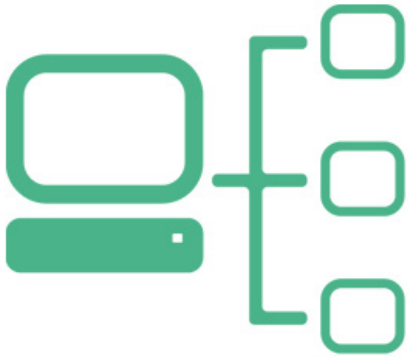


3 Recommendations for a Follow-up Report



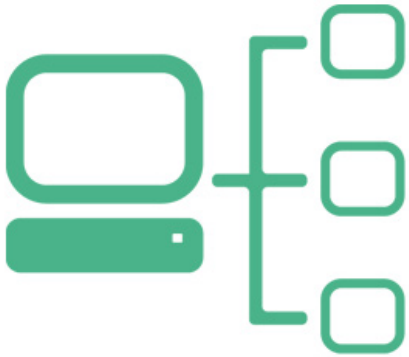
- Recommend that an international group such as IAEA attempt a follow-up report that would:
  - run each model using default parameters, common radionuclides, and several scenarios (e.g. subsistence farmer, suburban/urban residential, and commercial/ industrial workers)
  - run each model with same scenarios and radionuclides but with consistent parameters
  - include parameters which may have been too difficult to include in this study (e.g., soil to plant and plant to animal transfer factors)

Conclusion



- This study does not endorse any of the models or justify using certain default input parameters.
- To use a model, the regulatory frame under which the model was developed and parameter names and meanings should be taken into consideration.
- Some models use parameters and modules from other models => that's led us to the second project.

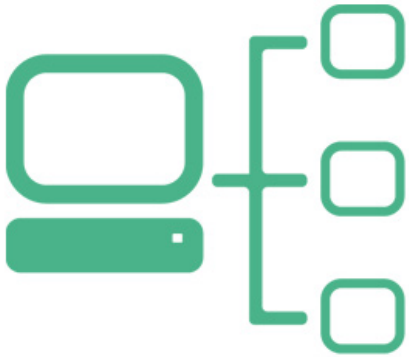
Second Project



Handbook of Parameters for U.S. and International Governments Risk and Dose Assessment Models for Remediation of Radiologically Contaminated Soil (PRG/DCC, RESRAD, NORMALYSA, RCLEA, RSRARS, WISMUT and NCRP)

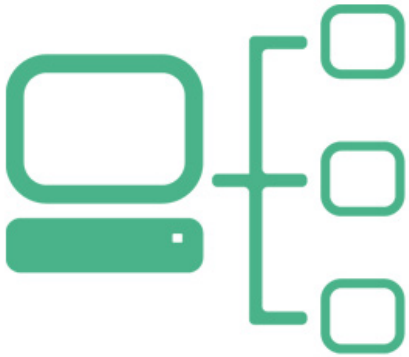
- The document for the second project shows a brief overview for the following models: PRG/DCC, RESRAD- ONSITE, NORMALYSA, RCLEA, RaSoRs, WISMUT and NCRP, and lists input parameters used by these models.
- It can be used as a parameters reference for modelers.

Third Project



Study of Chemical and Radiation Risk Assessment Methods for the United States Environmental Protection Agency and the Environment Agency of the United Kingdom

Background

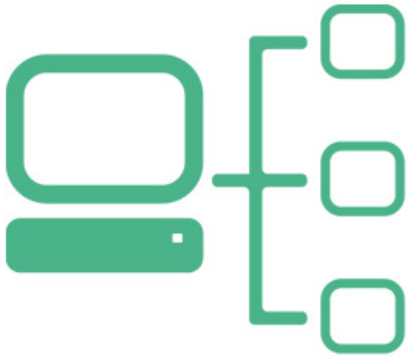


- The EPA's longstanding policy is that similar models should be used for the chemical and radionuclide risk assessments so that the results are consistent with summed assessments.
- Reasons why EPA uses the same methods for chemical and radioactive contamination:

1. Both contaminants are carcinogenic.
2. people ingest and inhale same amount of contaminated dust and food whether it is chemical or radioactive contamination.
3. dust gets resuspended the same whether it is chemically or radioactively contaminated
4. inorganic elements move through the subsurface whether they are radioactive or not.

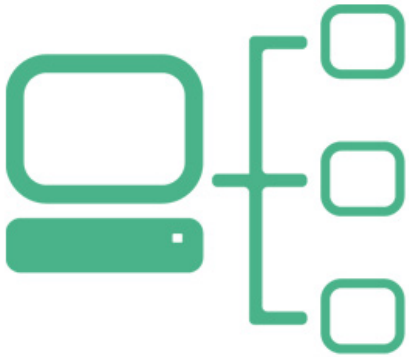
The US EPA uses "slope factors" instead of dose conversion factors to estimate cancer risk from radioactive contaminants

Why UK EA?



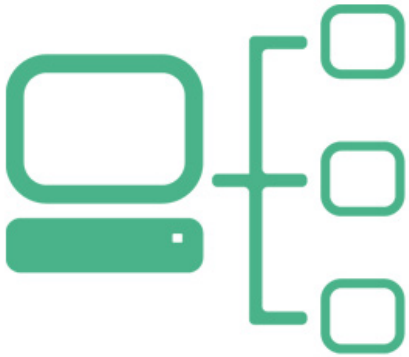
- By searching literatures and environmental agencies' websites, the UK EA was found to have to some extent consistent methods for radionuclides and chemicals assessment tools with the exception that the outputs of the tools are different.

Radiation and Chemical Assessment Tools



- U.S. Environmental Protection Agency (EPA)
  - Preliminary Remediation Goal (PRG)
  - Regional Screening Levels (RSL)
- U.K. Environment Agency (EA)
  - The Radioactively Contaminated Land Exposure Assessment Methodology (RCLEA)
  - Contaminated land exposure assessment (CLEA)

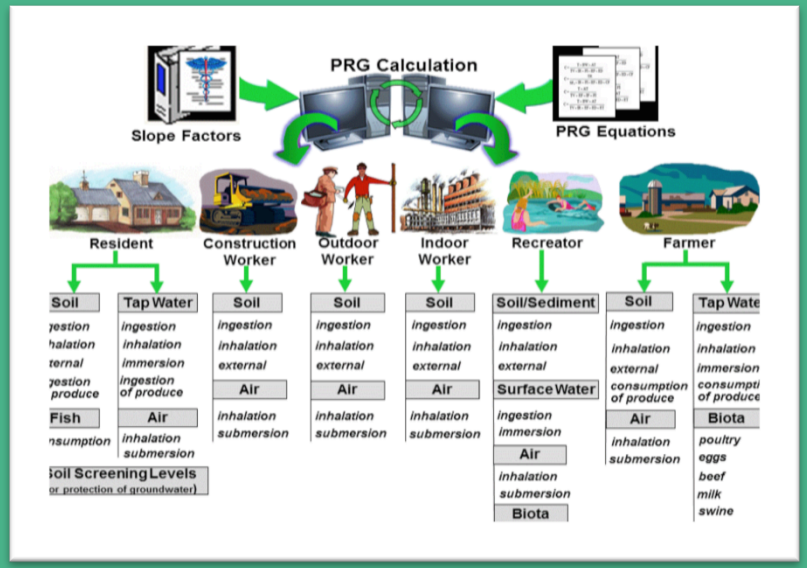
Outline



- Overview of risk assessment tools.
- Key similarities and differences between the U.S. EPA models, PRG and RSL calculators.
- Key similarities and differences between the U.K. EA models, RCLEA and CLEA.
- Comparison between the US EPA and the UK EA.

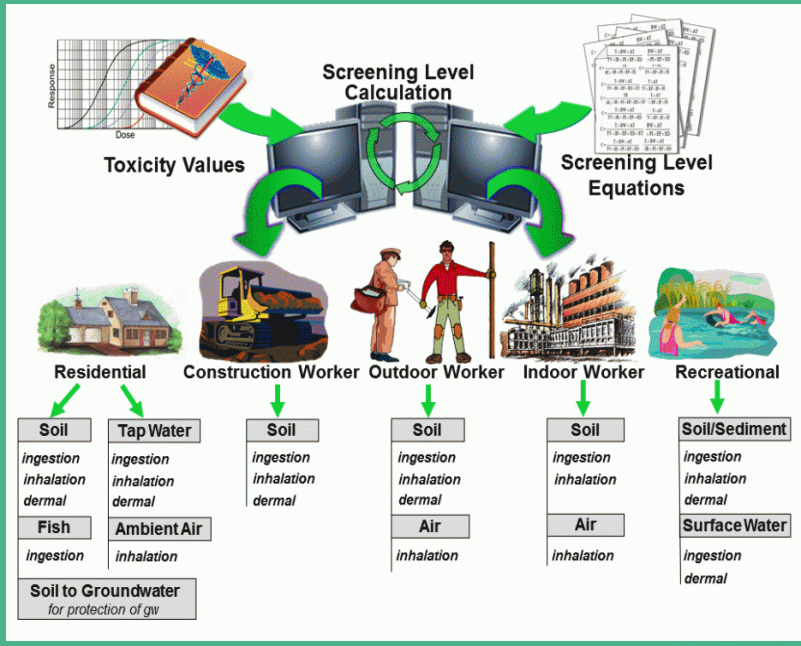
PRG Calculator

- Developed by the U.S EPA in 2002 and last updated in 2017
- The PRG calculator is risk-based tool.
- Used for calculating radionuclide PRGs for residential, commercial/ industrial, and agricultural land use exposures from soil, tap water and air



RSL Calculator

- The EPA developed the Regional Screening Levels (RSL) for Chemical Contaminants in soil, water, and air at Superfund Sites.
- The RSL calculator is risk-based calculator.
- The RSL website includes generic tables for several scenarios and also can perform site-specific screening.



Key Similarities between PRG and RSL

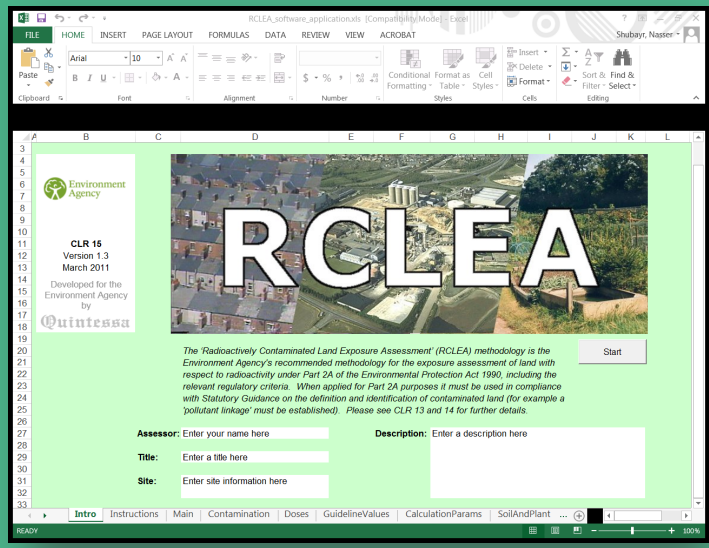
- PRG and RSL are both online calculators found at the EPA website.
- PRG and RSL are both deterministic models.
- PRG and RSL have similar scenarios and default input parameters.
- PRG and RSL have additive cancer risks. Both have default target of 1×10^{-6} for each contaminant.

Key Differences between PRG and RSL

- RSL does not include:
  1. produce or farm animal consumption that are in the PRG.
  2. farmer scenario.
- RSL accounts skin absorption while PRG accounts for external (gamma) exposure.
- RSL addresses noncancer risks, including total uranium; PRG does not address noncancer risks

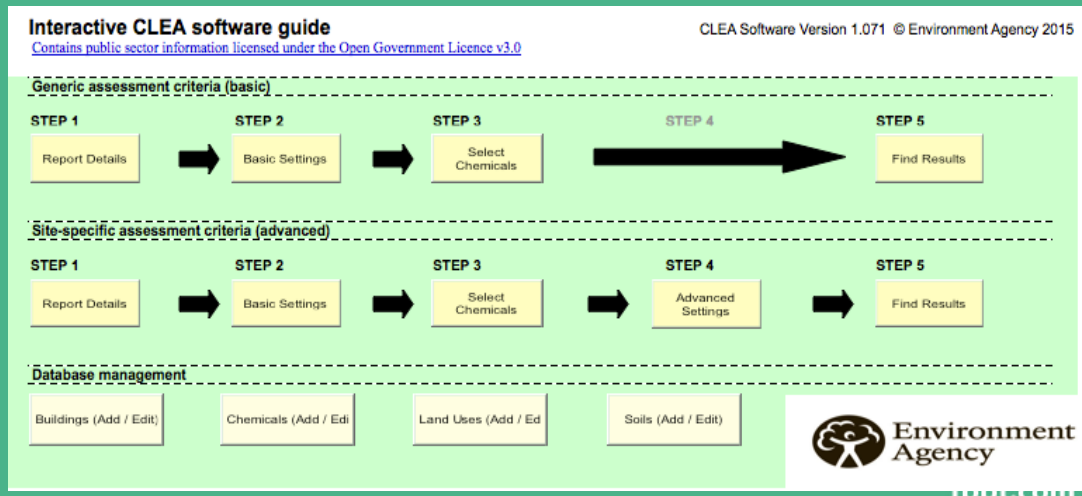
RCLEA

- RCLEA was developed by DEFRA's (U.K. Government Department for Environment, Food and Rural Affairs) in 2003
- RCLEA consists of a collection of worksheets (pages) that contain all input data and results.
- RCLEA considers a set of 47 radionuclides that are commonly found in radioactively contaminated sites in the UK.



CLEA

- CLEA was also developed by DEFRA for managing contaminated land in the UK.
- It can perform a generic or site-specific assessment to assess chemical contamination in soil.



Key Similarities between RCLEA and CLEA

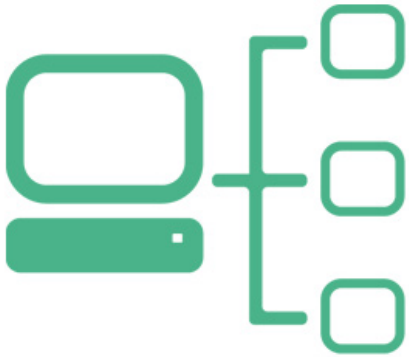
- Both are deterministic models implemented in a Microsoft Excel® workbook.
- Uniform contamination to a depth of 1 m from the surface.
- Same land uses: (Residential with Home-Grown Produce, Residential without Home-Grown Produce, Allotment, and Commercial/Industrial)
- Same building types.
- Same exposure pathways, with the exception of skin absorption pathways.
- Same default input parameters equations.
- Both do not consider the ingestion of animal products.

Key Differences between RCLEA and CLEA

- The CLEA outputs (Soil Guideline Value) for chemical contaminants are contaminant-specific and not additive, while in RCLEA, the radiation doses from multiple radionuclides are additive and compared with a single exposure criterion.
- The CLEA includes data for 18 different age groups, while RCLEA includes only three (Infant, Child and Adult).
- The CLEA adopts several soil types with one default soil type (sandy loam soil), while RCLEA adopts a single soil type.
- The CLEA consider the absorption of chemicals through skin while RCLEA dose not.
- The RCLEA includes two additional exposure pathways:
  1. whole body external exposure from a distance.
  2. irradiation of the skin from direct contact with contaminated material.
- The RCLEA adopts a higher concentration of atmospheric respirable particulates in comparison with CLEA.

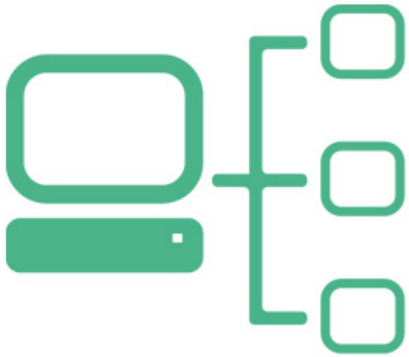
Comparison between the US EPA and UK EA		
	US EPA	**UK EA**
1	PRG and RSL, are both internet calculators	RCLEA and CLEA, are both implemented in an Excel® workbook.
2	PRG and RSL both have a target risk of $1x10^{-6}$ for each contaminant,	RCEA & CLEA do not have the risk additives.
3	PRG and RSL have similar scenarios, except farmer scenario is not available in RSL.	Similarly, RCLEA and CLEA use similar scenarios/ land uses.
4	PRG and RSL, are both deterministic	The same approach.
5	PRG and RSL have consistent default input parameters and equations	The same approach.
6	The U.S. EPA chemical model, consider skin absorption but do not consider this pathway for the radiation models.	The same approach.

Conclusion



- **<u>The major difference between US EPA and UK EA is the Outputs (results) of the assessment tools.</u>**
- US EPA has the same outputs (risk target of $1x10^{-6}$) and can be summed for radiation and chemical contaminants.
- UK EA has different outputs, RCLEA (mSv) and CLEA (mg kg^{-1}), and cannot be summed.
- **<u>Why?</u> It is a policy!**
  In the UK, legislation is driven by European Union directives that separate the radioactive contamination and non-radioactive contamination.

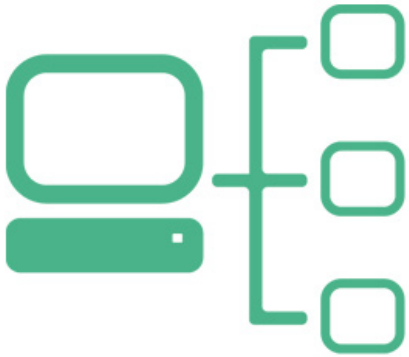
Fourth Project



Comparing Radiation Risk Assessment Models for Radioactively Contaminated Buildings

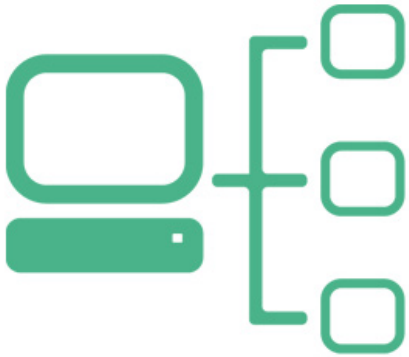
(BPRG/BDCC and RESRAD-BUILD)

Introduction



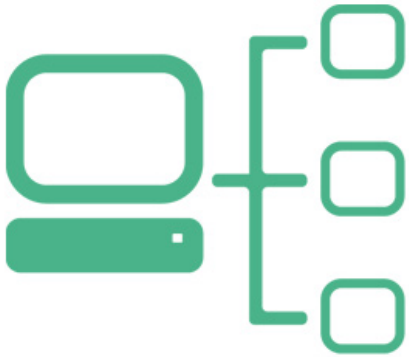
- The US EPA and US DOE have developed models to assess the risk from radioactively contaminated buildings. The two agencies' modeling approaches and input parameters are different.
- This study shows the methodology of each agency.

Preliminary Remediation Goals for Radionuclides in Buildings (BPRG)



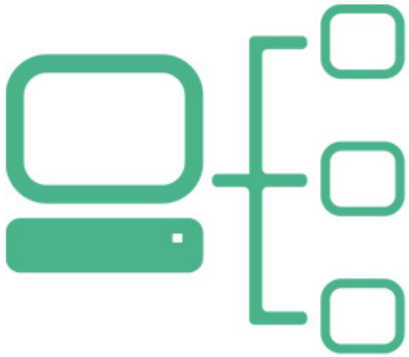
- Developed by EPA to help assess the need for cleaning up a radioactively contaminated buildings.
- risk-based tool.
- generic or site-specific.

RESRAD-BUILD



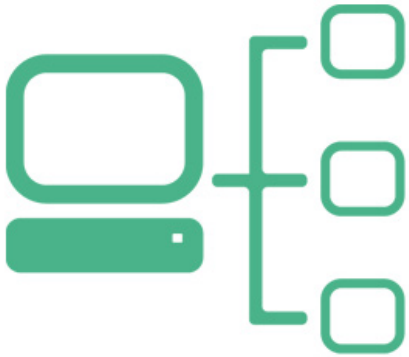
- Developed by Argonne National Laboratory, US DOE in 1994.
- To assess the potential radiological dose for exposed individual who works or lives in a radioactively contaminated building.
- Can perform both deterministic and probabilistic assessment.

Comparison



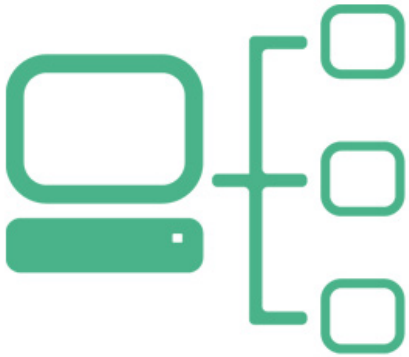
- Exposure scenario and pathways.
- Building descriptions,
- Source descriptions,
- Outputs.
- Default input parameters.

Exposure Scenario and Pathways



- BPRG/BDCC calculators are based on the receptors, such as resident and indoor worker, while
- RESRAD-BUILD is mainly based on potential uses of a building, such as building occupancy and building renovation.

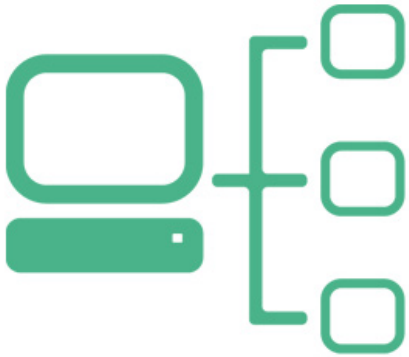
BPRG/BDCC Exposure Scenarios and pathways



BPRG/BDCC calculators use two scenarios: 1) Resident (adult and child) and 2) Indoor Worker (adult), and three exposure pathways for each scenario:

- **Exposure to Settled Dust on Surfaces**
  - external exposure and
  - ingestion of dust when hands contact dust-laden surface and then come in contact with the mouth
- **Exposure to Ambient Air**
  - inhalation of air.
  - submersion. (Submersion is external exposure from the contaminated air).
- **3-D Direct External Exposure**
  - Direct external exposure from radioactive contaminants in the building materials of the walls, floor and ceiling.

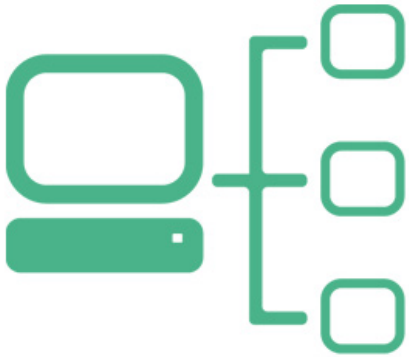
RESRAD-BUILD Exposure scenarios and pathways



1. Building occupancy (residents, office workers, industrial workers, and visitors
2. Building renovation: (decontamination workers, building renovation workers, and building demolition workers).

- Exposure pathways in the RESRAD-BUILD:
  - external exposure to penetrating radiation emitted 1) directly from the source, 2) radioactive particulates deposited on the floors of the compartments, 3) due to submersion in airborne radioactive particulates.
  - Inhalation: 1) airborne radioactive particulates, aerosol indoor radon decay products and tritiated water vapor.
  - inadvertent ingestion of radioactive material 1) contained in removable material directly from the source, 2) particulates deposited on the surfaces of the building.

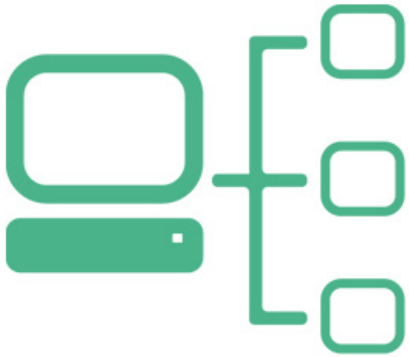
BUILDING DESCRIPTION



Building description includes:

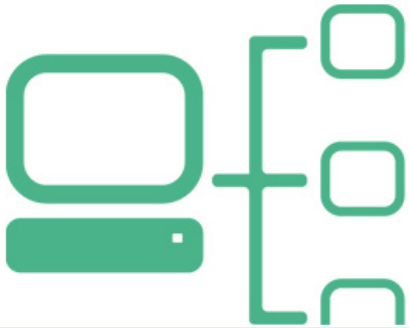
- Number of compartments and their positions.
- Building and Shielding materials.
- Dimensions of the compartment.

BPRG/BDCC BUILDING DESCRIPTION



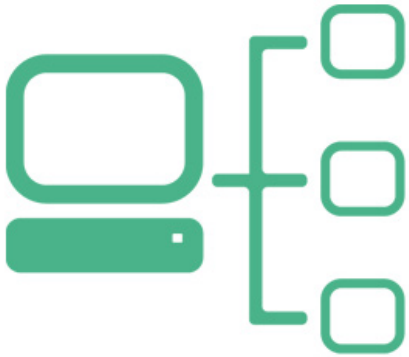
- One compartment for each calculating run.
- The building gamma-shielding factor is set at one, which indicate that there is no shielding.
- Three features can define the compartment;
  - room material,
  - room position and
  - room size.
- The default (isotope- specific) is the most protective value given the three features.

BPRG/BDCC BUILDING DESCRIPTION



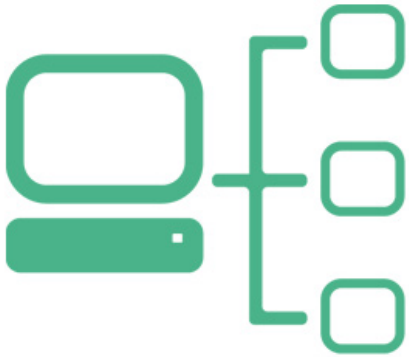
Room material:	Room position	Room size (ft)
1. Adobe 2. Composite 1 room material: drywall room, glass window, wooden doors, drywall walls, concrete floor, drywall ceiling 3. Composite 2 room material: concrete room, wooden doors, concrete floor, drywall ceiling 4. Concrete 5. Drywall 6. Glass 7. Wood 8. Default (isotope -specific)	1. Average 2. Center 3. Center wall 4. Corner 5. Default (isotope -specific)	1. 10x10x10 2. 50x50x50 3. 100x100x10 4. 200x200x20 5. 400x400x40 6. Default (isotope -specific)

RESRAD-BUILD BUILDING DESCRIPTION



- Up to three compartments. It can evaluate wide range of situations such as one-room warehouse, a two-room house or apartment, a three-room ranch house, a three-story office building, or a two-story house with a basement.
- Eight shielding materials (concrete, water, aluminum, iron, copper, tungsten, lead, and uranium). Concrete is set as the default shielding material.
- Can display the compartment in 3-Dimensions.

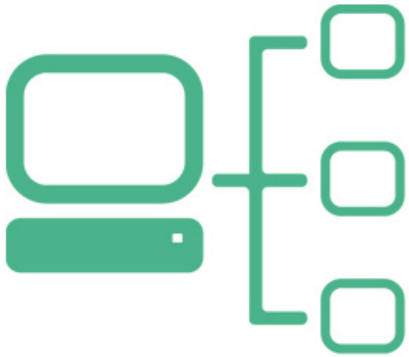
SOURCES DESCRIPTIONS



- **BPRG/BDCC Calculators SOURCES DESCRIPTIONS:**
  - contain 1255 radionuclides with 18 commonly found radionuclides.
  - The source is defined as: Area and Volume.

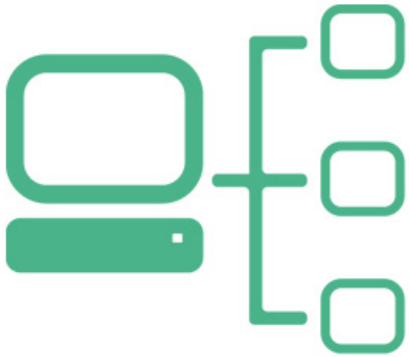
- **RESRAD-BUILD SOURCES DESCRIPTIONS:**
  - considers 67 principal radionuclides and 53 progenies (total 120 radionuclides).
  - The model defines several sources: (Point, Line, Area, Volume)

Outputs



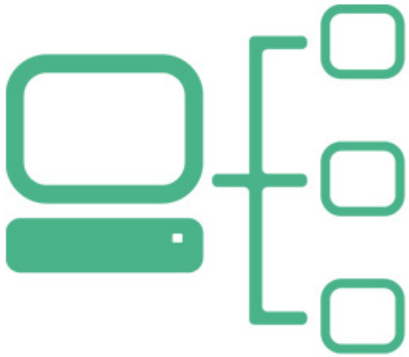
- **BPRG/BDCC Outputs:**
  - Generic tables with parameters used.
  - Site-specific tables. with parameters used.
- **RESRAD-BUILD Outputs:**
  - Summary report provides:
    - Parameter used
    - Source term
    - Dose
  - Detailed Report:
    - Intermediate calculations involving airflow
    - Injection rates
    - External dose parameters
  - Graphical Results:
    - Interactive plotting

Comparison of Parameters for BPRG/BDCC and RESRAD-BUILD



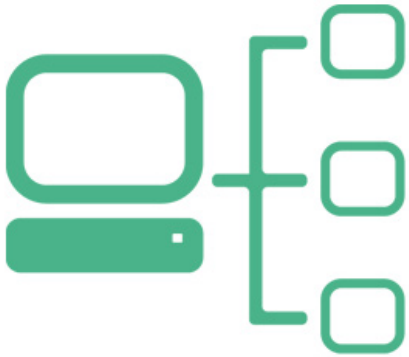
- Occupancy Factors
- Inhalation Rates
- Ingestion Rates
- Shielding Factors

Fifth Project



Overview of Radiation Risk Assessment Models for Radioactively Contaminated Surfaces (SPRG/SDCC, RESRAD-RDD, ERMIN).

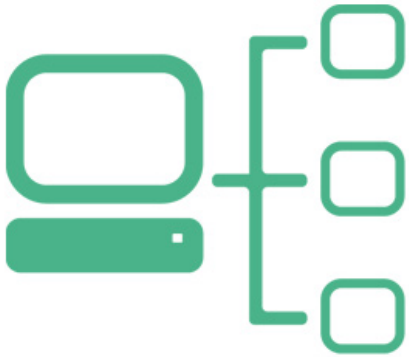
Introduction



- Radiation assessment models for contaminated surface have been developed by many agencies to support decision-making process.
- These models have been developed for different main purposes but tackle the same issue, surface contaminations.
- This project addresses a review of the following models:

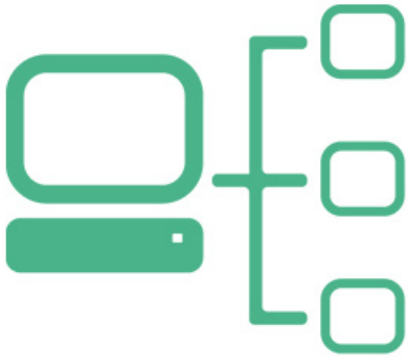
1. The U.S. Environmental Protection Agency: SPRG/SDCC,
2. The U.S. Department of Energy: RESRAD-RDD, and
3. The European Approach to Nuclear and Radiological Emergency Management and Rehabilitation Strategies (EURANOS): ERMIN.

Preliminary Remediation Goals for Radionuclides in Outdoor Surfaces (SPRG)



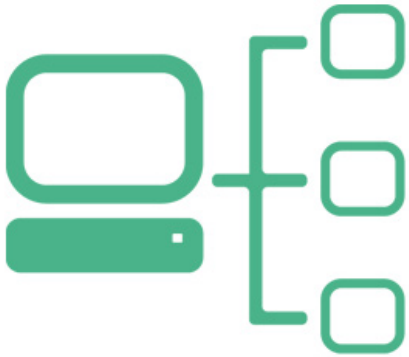
- Developed by the U.S. Environmental Protection Agency.
- Risk-based tool.
- Outdoor hard surfaces such as buildings, slabs, outside building walls, sidewalk and roads.
- Contain 1255 radionuclides.

SPRG Exposure Pathways and Scenarios



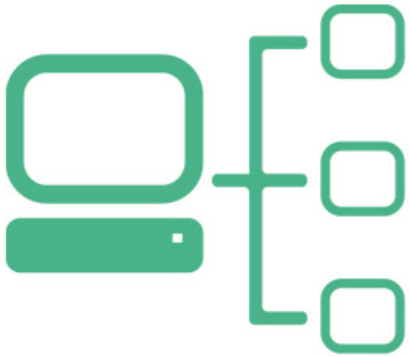
Scenario	Media
Resident **Composite worker** **Outdoor worker** **Indoor worker**	• Exposure to Settled Dust (external and ingestion), • Ambient Air (inhalation and external), • 2 -D external exposure. • 3-D external exposure.

RESRAD-Radiological Dispersal Device (RDD)



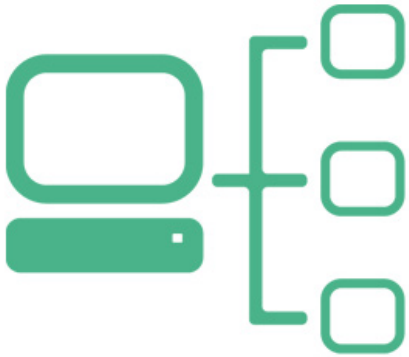
- Developed by Argonne National Laboratory for the U.S. Department of Energy (DOE)in 2009.
- To assist decision making after radionuclides release in an RDD incident.
- Assumed the deposition on multiple surfaces including street (urban), soil (rural), roof, exterior wall, interior floor (urban), interior floor (rural) and interior wall of buildings in the affected areas.
- 11 radionuclides that are most likely involved in an RDD incident.

RESRAD-RDD Exposure Pathways and Scenarios



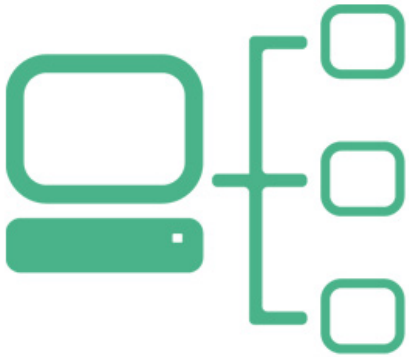
1. External exposure to contaminants on streets/soils while staying outdoors,
2. External exposure to contaminants on outdoor surfaces while staying indoors.
3. Inhalation exposure while staying outdoors or indoors.
4. Submersion in contaminated air while staying outdoors and indoors.
5. Ingestion of dust particles on streets/soils while staying outdoors, while staying indoors, from the floors or walls
6. Radon inhalation while staying indoors.

The European Model for Inhabited Areas (ERMIN)



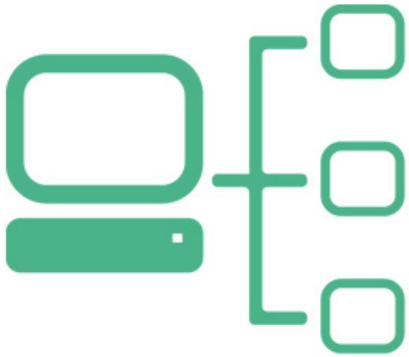
- Developed by European Approach to Nuclear and Radiological Emergency Management and Rehabilitation Strategies (EURANOS).
- Can be used by decision-makers to assess different recovery options following radioactive contamination of an urban environment.
- ERMIN is a standalone tool but also designed to be implemented within other nuclear accident Decision Support Systems (DSS) such as the RODOS and ARGOS

ERMIN Exposure Pathways and Scenarios



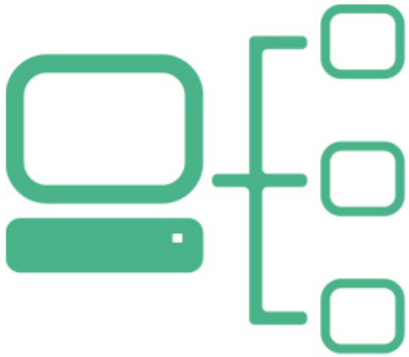
- The average doses to members of the public from external exposure to gamma and beta radiation from deposited radionuclides and inhalation of resuspended radioactivity.
- The contamination on urban surfaces.
- The activity concentration in air from wind resuspension.
- The doses to workers undertaking the recovery work.
- The quantity and activity of waste generated.
- The cost and work required to implement the countermeasure.

Resuspension modules in SPRG, RESRAD-RDD and ERMIN



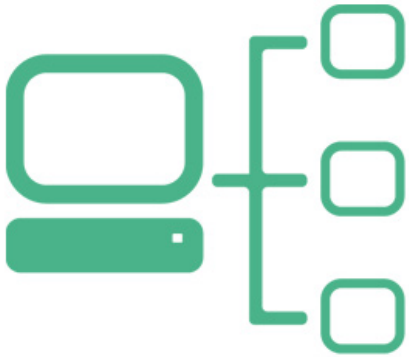
- SPRG:
  - mechanically driven resuspension
  - wind driven resuspension.
- The mechanic resuspension is a unique modeling approach. It is assumed that dust is being resuspended from the road surface by vehicles, it is specific for 50 US States and whether the roadway is located in Rural or Urban area. Each roadway area includes six roadway classes (Interstate, Other Principal Arterial, Major Collector, Minor Collector and Local).
- The default value is based on California Urban Interstate average daily traffic volume (most conservative).

(cont.) Resuspension modules in SPRG, RESRAD-RDD and ERMIN



- RESRAD-RDD:
  - wind driven resuspension.
  - mechanically driven resuspension (wind driven resuspension multiplied by 10 to account for vehicular traffic and a factor of 100 for unpaved road.
- ERMIN:
  - wind driven resuspension only.

Questions?



Thank you!